

# **BOILER MANUAL**

LMCF00090



INSTRUCTIONS  
FOR  
OPERATION  
AND MAINTENANCE

ROSTER WHEELER CORPORATION

NEW YORK, N. Y.

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7. B.  
42-3

S.S. SPARTAN, Hull 369

and

S.S. BADGER, Hull 370

Built For

CHESAPEAKE and OHIO RAILWAY CO.

By

CHRISTY CORP.

FOSTER WHEELER CONTRACT FWB 3370-3 & 3396-9

Instruction Book FWB 3370-3

FOSTER WHEELER CORPORATION

165 Broadway

New York, N.Y.

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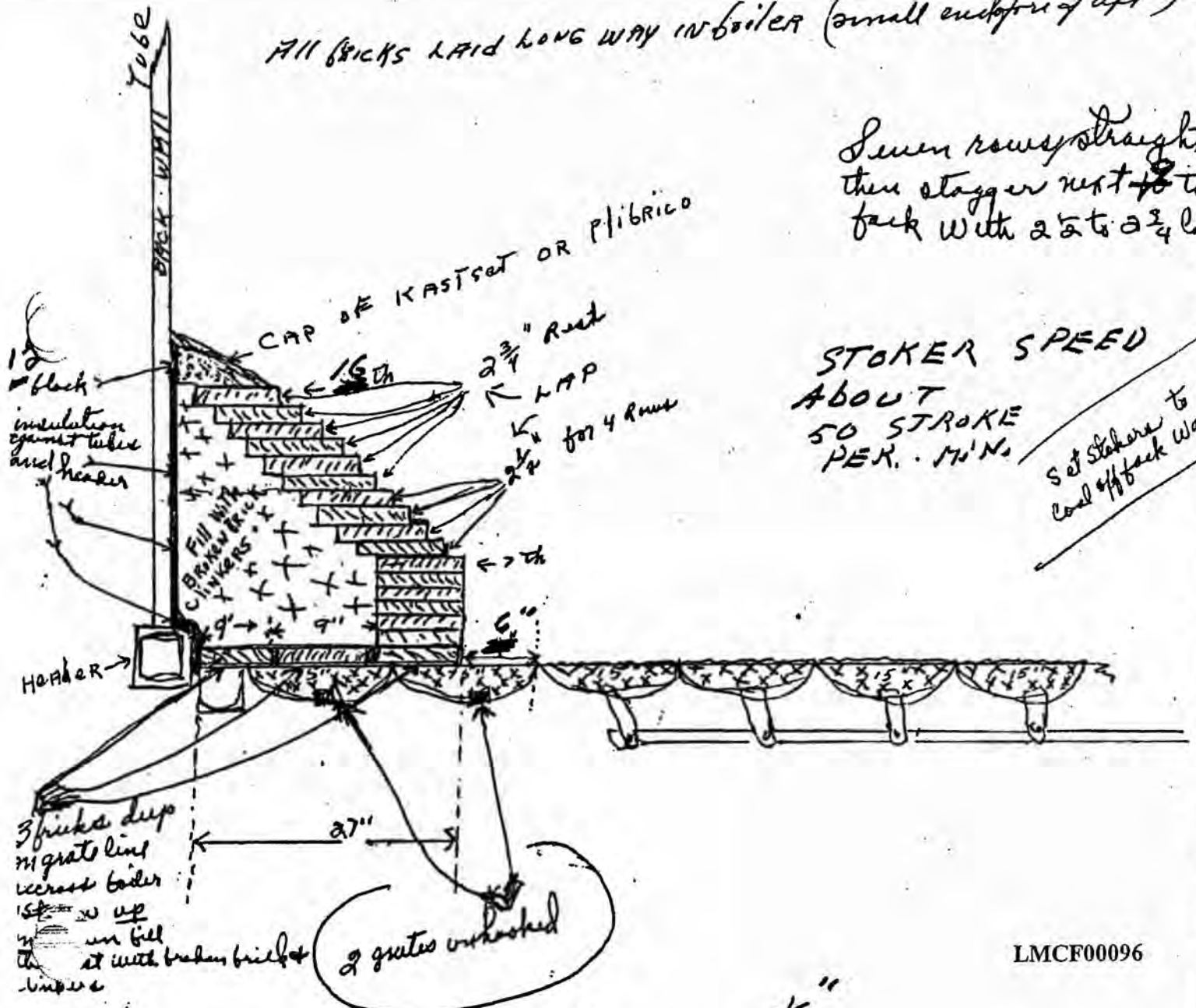
Block or plug  
of air nozzles that wall  
covers

All bricks laid long way in boiler (small end of aft)

Seven rows straight  
then stagger next to  
back with 2 1/2 to 3 1/4 in

STOKER SPEED  
ABOUT  
50 STROKE  
PER. MIN.

Set stokers to  
coal off back wall



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INSULATE between tubes & wall both side & back use 1 1/2" block insulation - insulate hearth also

## BOILERS - Steamers 42 and 43

4 boilers each ship - 2 right hand, 2 left hand

Foster-Wheeler Type D 2 drum FWB 3370-3 and 3396-9. Design

500#, operating pressure 450#, final temp. 740°, feed water

225°, year 1950. Heating surfaces. Boiler 4475 sq. ft.

Water Wall 340 sq. ft.

Economizer 2860 sq. ft.

Total 7675 sq. ft.

Superheater 720 sq. ft.

Furnace

volume 880 cu. ft.

Grate sur. 101 sq. ft.

Weight of water per boiler @ steam level 16,500 lb.

Performance	Normal	Maximum
Total evap. ea. boiler lbs/hr.	29,500	44,000
Superheater outlet temp. °F.	750	760
Total draft loss thru boiler inc. grates & econ. H <sub>2</sub> O	1.7	3.7
Air temp. under grates	100°	100°
Radiant heat absorbing surface	325 sq. ft.	
BTU/sq.ft. RHA surface	126,000	
Liberation BTU/cu.ft.	49,350	
Total volume	830 cu. ft.	
Soot Blowers-Vulcan Model P-3 size 2"		
Feed regulators-Swarthout 2½" 600# Thermo hydraulic S.C. Type SM		

One forced draft fan for each boiler.

Belt driven by 20 H.P. electric motor 1800 RPM, fan speed 1080 RPM

Clarage Vortex Control Single Inlet Type W, size 3 Design 2

Capacity 20600 CFM @ 3½ w.g. @ 100° F.

One induced draft fan for each boiler Prat-Daniel #110 Type 1

SWSI, KWS design with Multi-Clone Collector #6HC-1-70. Belt

driven by Terry Turbine.

Performance - barometric 30" H.G.

lbs steam	30,000	44,000	fan design
lbs gas per hr.	52,400	72,000	86,400
R.P.M.	764	1,130	1300
temp.	340	390	410
draft	3.21	6.63	8.25
B.H.P.	28	39.	61.4

General Regulator Combustion Control Electronic relay type.

Completely independent stack duct for each boiler.

PART I - DESCRIPTION OF STEAM GENERATORS

FOSTER WHEELER CONTRACT FWB 3370-3 & 3396-9

DESIGN DATA  
(Section I-1)

TYPE: Foster Wheeler "D" Type

THE STEAM GENERATOR INCLUDES:  
Boiler, Waterwalls, Superheater,  
Economizer, Soot Blowers, Valves  
and Fittings, Feed Water Regulators

Four (4) Steam Generators are  
Installed Per Vessel.

FUEL: Coal

PRESSURE: Lb. psi

Design.....	500
Hydrostatic test.....	750
Hydrostatic test for desuperheaters.....	300
Superheater Outlet.....	450
Safety Valve Setting steam drum.....	475
and.....	470
Safety Valve Setting superheater outlet.....	450

TEMPERATURE: Normal Full  
Power Deg. F.  
Final temp. at super-  
heater outlet.....750  
Feed Water Temperature 225

HEATING SURFACES: SQ. FT.  
Boiler..... 4475  
Waterwall..... 340  
Economizer..... 2860  
Total Water Heating  
surface..... 7675  
Superheater ..... 720

GRATE SURFACE: SQ. FT. 101

WEIGHT PER BOILER:

At steaming Temperature Lbs.  
Boiler Dry.....146,970  
Water Normal level.. 16,500  
Total.....163,470

Weight of Water Full 20,390

BOILER PERFORMANCE

	<u>NORMAL</u>	<u>MAXIMUM</u>
Total Evaporation, ea. boiler lbs/hr	29,500	44,000
Superheater outlet temperature-Deg. F.	750	760
Feed Temperature - Deg. F.	225	225
Total draft loss through boiler including grates and economizers H <sub>2</sub> O	1.7	3.7
Air temperature under grates - Deg. F.	100	100

## GENERAL

(Section 1-2)

The steam generators on this contract are of the "D" type design, two left hand and two right hand, designed for coal firing. Each steam generator includes a two drum bent tube boiler section, side waterwalls, rear waterwalls, convection type superheater, and an extended surface economizer. A desuperheater which supplies low temperature steam to auxiliaries, is installed in the steam drum below the normal water level.

The superheater is located behind the first three rows of 2" boiler tubes and in front of the bank of 1 1/4" generating tubes. It consists of U-bend elements rolled into headers which are parallel to the boiler tubes. The superheater elements extend across the boiler, at right angles to the boiler tubes.

The economizer is located inboard and above the generating tube bank and arranged for three parallel water circuits through the unit.

The rear of each boiler is fitted with a double casing. Air leaving the blowers passes through this double casing, absorbs heat from the furnace inner casing, and enters the furnace below the grate area.

The products of combustion formed in the furnace make a single pass through the screen tubes, superheater, and large bank of generating tubes, then upward through the economizer to the uptake.

## COMPONENTS

(Section 1-3)

### Drums

The nominal inside diameter of the steam drum is 48" with a wrapper sheet 7/8" thick and a tube sheet 2 1/2" thick. The water drum has an inside diameter of 30" with a shell thickness of 1-9/16".

### Waterwalls

The furnace is water cooled on the roof, side wall and rear wall with 2" tubes. These tubes form heat absorbing sur-

faces which protect refractory and at the same time provide additional boiler heating surface.

Circulating water for the rear waterwall is provided by means of three 4" O.D. feeder tubes which are expanded into the lower rearwall header. Two of these 4" tubes lead from the steam drum, below the water level, and one 4" tube leads from the water drum.

The side waterwall is supplied by means of five 4" O.D. feeder tubes which lead from the water drum to sidewall header. These side and rearwall feeders are shown in Part I, Section 1-8 of this manual on drawing NY 500-470.

A tube list in Part I, Section 1-6 of this manual gives size, number, and quantity of all tubes installed in these steam generators.

### Furnace

The furnace is of ample size for burning the required quantity of fuel without excessive heat release. The side wall, rear wall, and roof of the furnace are lined with water tubes backed up by tile, high temperature insulating block, mineral wool blanket, and the outer casing. The front wall of the furnace is lined with refractory blocks backed up by high temperature insulating blocks, and the casing.

### Refractory

Drawing No. NY 500-719 in Section 1-8 of this manual shows in detail the arrangement of brickwork and insulation furnished on this contract. Maintenance of refractory is completely described in Section 3-7.

### Superheater

The superheater is located in the generating tube bank behind the screen tubes. It is a three-loop, four-pass type, consisting of 104 U-bend elements rolled into the superheater headers.

Each header is fitted with a 3/4" drain valve and the header diaphragms are perforated with a small drainage slot; to provide complete drainage.

The superheater elements are supported by alloy plates placed parallel to the gas flow and extending from the steam drum to the water drum. The support plates are secured to four 3" superheater support tubes. The superheater elements pass through holes in these support plates.

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Steam enters the outboard superheater header at the bottom, makes four passes through the loops, leaves at the top of the outboard header, and flows to the main steam line and desuperheater inlet.

The 2" superheater safety valve is installed in the piping between the superheater outlet and the stop valve.

### Economizer

The economizer is of the counterflow, extended surface, three pass type. It consists of a series of "U"-bend horizontal elements, which have their longitudinal axis parallel to the boiler drum.

The ends of these economizer "U"-bend elements are connected by means of headers. The economizer ends are expanded into these headers, machined flush with the inside surface of the headers and seal welded. See Part III, Section 3-6, and drawings NY 500-439 and NY 500-440 in Part I, Section 1-8.

Each element is made by shrinking 5" O.D. cast iron rings on 2" O.D. x 9 BWG seamless steel tubes to form the extended heat absorbing surface. These elements are installed through the front tube sheet.

Each economizer is fitted with an inlet manifold header, an outlet manifold header, a 1/2" vent and a 3/4" drain.

Two steam soot blowers are provided for keeping the economizer elements clean.

### STEAM DRUM INTERNALS (Section 1-4)

#### Desuperheater

A desuperheater is installed in the steam drum of each steam generator to supply low temperature steam required for auxiliary equipment, and to protect the superheater at low ratings by maintaining steam flow through the superheater. The desuperheating is accomplished by the cooling action of the water in the steam drum which absorbs heat from the superheated steam.

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The desuperheater consists of 2" pipe which makes four lengthwise passes below the normal water level in the drum. The ends are connected to inlet and outlet connections located at the rear of the drum.

Due to the higher pressure in the drum than in the superheater, which would permit moisture and solids in the drum to be entrained in the auxiliary steam line in the event of a leaking joint, the desuperheater should be tested independently of the steam generator at a pressure of 300 psig.

#### Internal Feed Line

The internal feed line extends horizontally the length of the drum, below the normal water level. It is made of 2½" seamless pipe closed at the ends. The internal feed line has slots which are cut horizontally in the top for introducing feed water into the drum evenly throughout its length. The feed water inlet connection is located in the top of the drum as shown in Drawing No. NY 500-564 in Part I, Section 1-8 of this manual.

#### Dry Pipe

The dry pipe is suspended along the top center line of the steam drum. It consists of an 8" pipe closed at each end and perforated along its upper surface with 3/8" holes. In the bottom of the pipe, at each end, are 3/4" drain holes. Steam enters the dry pipe through the upper perforated area, thus preventing carry-over of moisture. Steam leaves the dry pipe through the steam nozzle in the top of the drum.

#### Continuous Blow-Down

A continuous blow-down pipe is placed near the bottom of the steam drum. It consists of 3/4" pipe which enters through a fitting in the rear head of the drum and extends approximately one-half the length of the drum. The end of the pipe is open. The purpose of the blow-down is to provide a means of reducing the density of the boiler water.

#### Surface Blow-Down

A 1½" surface blow-down pipe is located in the steam drum at the normal water level. The surface blow is used for removing scum, oil or grease from the surface of the water and for reducing high water level when the steam generator is in operation.

#### Plates and Baffles

Swash Plates are 3/16" plates placed in the steam drum of the boiler. They keep surging of water to a minimum by dividing the lower half of the drum into three separate, approximately uniform spaces.

Steam Baffle Plates are perforated plates placed at the normal water level in the steam drum to prevent foaming. The plates are horizontal. They extend the width of the drum and run about 2/3 its length.

AUXILIARY EQUIPMENT  
(Section 1-5)

The auxiliary equipment furnished on this installation by Foster Wheeler Corporation on this contract includes Crosby Safety Valves, Jerguson Gage Glasses, Vulcan Soot Blowers, Swartwout Feed Water Regulators, and Yarway Remote Level Indicators.

Manufacturer's instruction manuals covering description, operation, and maintenance of this equipment will be found at the end of this instruction manual under section entitled "Appendix". A complete listing of all valves and fittings furnished by Foster Wheeler is included in Part I, Section 1-8, Drawing No. NY 502-220, of this manual.

TUBE DATA - (FOR ONE STEAM GENERATOR)  
(Section 1-6)

1 1/4" O.D. x 12 BWG GENERATING TUBES

<u>Row No.</u>	<u>No. Per Row</u>
5	69
6	73
7	75
8	74
9	75
10	74
11	75
12	74
13	75
14	74
15	75
16	74
17	74
18	75
19	74
20	75
21	74
Total	1259

2" O.D. x 10 BWG TUBES

<u>Row No.</u>	<u>Location</u>	<u>No. of Tubes</u>
1	Sidewall	30
1A	"	29
	Total Sidewall Tubes -	59
2	Screen	13
2A	"	2
3	"	30
4	"	29
	Total Screen Tubes -	74
22 to 47 incl.	Rearwall	26
48 to 63 incl.	Rearwall Risers	16

4" O.D. x 6 BWG

<u>Tube No.</u>	<u>Location</u>	<u>No. of Tubes</u>
F1	Sidewall Feeders	4
F2	Sidewall Feeder	1
F3	Rearwall Feeder	1
F4	Rearwall Feeder	1
F5	Rearwall Feeder	1
Total	- -	8

DC1	Downcomer Tubes	2
DC2	"	2
DC3	"	2
DC4	"	2
Total	- -	8

3" O.D. x 6 BWG TUBES

<u>Tube No.</u>	<u>Location</u>	<u>No. of Tubes</u>
SS1	Superheater Sup.	2
SS2	Superheater Sup.	2
	Total Superheater Support Tubes	4

PERFORMANCE CURVE  
(Section 1-7)

DRAWINGS  
(Section 1-8)

General Arrangement	NY-500-439
Auxiliary Sections	NY-500-440
Steam Drum Internals	NY-500-564
Brickwork and Field Insulation	NY-500-719
Feeders and Rear-Wall Risers	NY-500-470
Spares and Tools Per Ship	NY-501-585
Valves and Fittings Per Ship	NY-502-220

## Part II — OPERATION

### PUTTING STEAM GENERATOR IN OPERATION

(Section 2-1)

The following procedure is a brief, easily remembered outline of the necessary steps to be taken in putting a steam generator in service for normal operation. If the unit is new, has been laid up, or has undergone extensive repairs refer first to the section "Putting New Steam Generator in Service." Section 2-6.

#### Lighting Off

**Valves** —Closed: Steam stop valves, surface and bottom blow, economizer vent and drain, waterwall drains.

Open: Gage valves, gage glass valves, superheater vent, superheater and desuperheater drains, air cock and feed stops.

**Feed** —Fill boiler with best available feedwater, (preferably 0.3 grains total solids per gal. or less) through auxiliary feed line until water appears in the lower gage glass. Continue until water raises one inch. Change over to main feed line, closing auxiliary check valve only, and fill to 3" in lower glass. This procedure checks both feed lines.

**Burners**—Inspect furnace floor for oil. Ventilate boiler thoroughly using forced draft fan to remove inflammable gases. Recirculate fuel oil until oil at proper temperature is available at the burners. Install the smallest sprayer plates in the atomizers furnished for type of oil with which the burner is designed to operate and using torch, light off one burner. Make sure the torch doesn't go out. Make sure the burner stays lit. If it goes out, don't attempt to light the burner again without first ventilating the furnace. Flarebacks happen this way.

#### Raising Steam

To prevent damage to the refractory and excessive temperatures in the superheater, it is

recommended that at least 3 or 4 hours be taken to put the boiler in service. However, in cases of extreme necessity the unit may be put in service more rapidly.

**Valves** —Main steam stop valves should be eased slightly to prevent sticking due to expansion. When steam issues forcibly from the air cock (approx. 20 lb.) it may be closed. A flow of steam must be maintained through the superheater. The superheater vent valve should be wide open when lighting off but may be closed-in somewhat as pressure rises to reduce amount of steam wasted. The superheater header drain valves and the desuperheater drain valve (if installed) should be cracked slightly so as to prevent accumulation of condensate. Blow the pressure gage line to check operation of the steam gage. Allow condensate to build up in line so that steam will not come in contact with gage and cause damage to it.

**Feed** —Check the water level by blowing down the gage glasses. Blow both upper and lower connections. As the boiler warms up, the level in the gage glass will rise. Do not allow it to rise out of sight in the gage glass. The water level may be lowered by using the surface blow. If a surface blow is not provided *put out the fires* and use the bottom blow. As the steam pressure rises it may be necessary to add water to make up for the loss through the vents and drains. If steam should be formed in the economizer, as indicated by water hammer, feed to clear the economizer and blow-down boiler if level becomes too high.

**Burners**—When bringing up steam it is advisable to rotate the burners. Use first one burner then change to another, allowing the brickwork to heat evenly for approximately 3 hrs. before full pressure is reached on boiler. This will necessitate burner shut-off periodically. Use a torch for lighting burners.

## FOSTER WHEELER STEAM GENERATORS

### Cutting in the Boiler

**Valves** —When the boiler pressure is within a few pounds of line pressure, warm up the steam lines slowly with the drains on the lines *open* using by-pass valves around the main stops if provided. On some boilers the pressure may be equalized through an auxiliary steam line. If not, ease the stop valves open slowly until first rush of steam subsides. *Do not close superheater vents or drains until boiler is on the line.*

**Feed** —The water level must not be too high when cutting in the boiler. If pressure in the line is lower than that in the boiler there is likelihood of carrying water over into the superheater. For this reason the superheater drains are left cracked open until boiler is on the line. Regulate feed supply or change to automatic regulator.

**Burners**—Change to proper size sprayer plates for steaming. Adjust air and oil supply and change to automatic combustion control if so equipped.

### Shutting Down

If possible use the soot blowers just before shutting down.

**Burners**—Extinguish the fires and remove burners. Allow the forced draft fan to run a few moments to clear the furnace of all gases, then shut it off and close all air registers. Allowing cold air to blow through the furnace will damage the brickwork and may cause casings to crack. Remove the atomizers for cleaning.

**Valves** —Open the superheater vent and crack superheater drain valve  $\frac{1}{4}$  turn. When the boiler pressure drops below line pressure the steam stop valves may be closed. When the steam pressure drops to approximately 20-25 lb. gage fully open the superheater drains (and de-superheater drains if fitted) and the air cock.

**Feed** —As the boiler cools down the water level will drop. Maintain the level at least

2 in. in the low glass. Unless absolutely necessary, do not use cold feedwater to cool down a boiler. When the boiler is cold close the feed stops. The steam stop valves can usually be tightened when the boiler has cooled but should be eased up when lighting off again.

### SAFETY

(Section 2-2)

Safety should be the first consideration in boiler operation. Accidents are often costly, not only to boilers, but also by causing delays in sailing of the vessel. The most frequent and most serious accidents are caused by low water and flarebacks. The competent operator will avoid dangerous situations and eliminate careless practices that may lead to damage or injury. The best accident prevention is to be thoroughly informed with the construction and proper operation of the boiler and the auxiliary equipment. Also, in an emergency, knowing what to do may eliminate serious damage.

Good operation not only increases safety but pays dividends in reduced maintenance expense.

### OPERATING PRECAUTIONS

(Section 2-3)

The outline in Section 2-1 is purposely brief as it is intended to serve as a guide for the proper sequence of steps performed in lighting off and raising steam. It is supplemented by the following additional precautions.

If the boiler is equipped with automatic combustion control, shift to manual operation before lighting off. When lighting off, it is difficult to completely eliminate smoke while the furnace is cold. Too much air, in an effort to stop the smoke, is likely to result in unburned oil vapor being deposited on the boiler, air heater and economizer surfaces. As the boiler heats up this vapor is driven off and secondary combustion may occur. The heat of this secondary combustion can cause warped casings, baffles and supports, and if severe, tube failure.

Too little air at any time will cause the boiler to "pant". Allowing this to continue will loosen the casings with resultant gas leaks and damage to the refractory. "Panting" can also occur under certain conditions of poor mixture of air and oil, or water in the fuel oil.

*Never light a burner from the hot brickwork.* This practice may result in serious damage and personal injury, due to explosion.

Keep the superheater vent open to assure steam flow through the superheater. It is just as important as water in the boiler. The superheater thermometer is not a reliable indicator of the temperatures in the superheater when raising steam.

Decrease the firing rate and increase the feed for a few moments if steaming, which causes water hammer, occurs in the economizer. Continued water hammer can cause leaks in the feed piping, economizer return headers and return bends.

Use the surface blow to reduce high water level. Do not use the bottom blow or open the water wall drains unless all the fires are extinguished. For most effective use of the bottom blow, first, open the valves in the blowdown line then open the boiler blowdown valve wide. When blowing operation is completed, close valves in reverse order. When operating either the surface or bottom blowdown valve, open valve wide and operate quickly while opening or closing.

*The normal water level, unless otherwise specified, is at the centerline of the steam drum.* Carry normal water level as the perforated baffles of drum internals are designed to function best at this level. Be suspicious of a water level that does not fluctuate. Check gage glasses frequently whether on manual or automatic operation. Check carefully gage glasses that appear completely full or completely empty as either may cause serious damage to equipment.

*If there is an unaccountable drop in the steam pressure, check the water level in the boiler by blowing the gage glass before increasing firing rate. Steam pressure will drop when there is insufficient water in the boiler.*

When maneuvering anticipate changes in the water level due to changes in steam demand. A sudden increase as from "stop" to "full" will result in a sharp rise in the water level. The feed should not be decreased but rather increased to keep up with the demand for steam. If the feed is decreased and the water level allowed to fall, the water may drop out of sight when the firing rate is suddenly decreased. Conversely, carrying the water level too high at low loads may result in the water going out of sight in the top of the glass. This

may cause a sudden drop in superheat temperature and leaking of the main steam line joints.

Carryover may also occur due to foaming, a condition caused by a high percentage of dissolved solids in the boiler water. Boiler feedwater must be pure, free of dissolved solids, oil and oxygen. Use distilled water only, if possible, for all makeup feed. Samples of boiler water should be tested twice daily. Proper alkalinity should be maintained to prevent corrosion. To prevent priming, blow down the steam generator if the total concentration of dissolved solids exceeds 500 parts per million (30 grains per gal.) or if the amount of scale forming salts is excessive.

To maintain low boiler water concentration, use continuous blow when installed or the surface blow. Otherwise shut off fires and use the bottom blow.

Do not permit oil, especially that containing vegetable fats, to enter the boiler as the insulating film formed on heating surfaces will result in blistering and eventual rupture of the affected tubes. Sludge, rolled into small, hard balls found in the waterwall headers, is an indication that oil is getting into the boilers.

Dissolved oxygen may cause pitting and corrosion at and above the waterline in the drum and also in the economizer. On vessels equipped with deaerators, the oxygen content of the feed should be tested periodically as a check on deaerator operation and should never be more than .03 cc per liter. To avoid oxygen pitting, maintain the design feedwater temperature, particularly in port. Feedwater below design temperature is very likely to contain oxygen. Vessels not equipped with a means of removing oxygen from the feedwater must chemically treat the boiler water.

Boiler treating chemicals are preferably introduced into the drum through a chemical feed line rather than through the economizer as the chemicals may possibly settle on the inner surface of the economizer tubes.

It is most important that the recommendations of a competent feedwater treatment concern are followed.

The soot blowers should be used twice daily or as often as necessary as indicated by changes in the stack temperature or in the draft loss. A temperature drop of more than 20 deg. F. after blowing tubes might indicate the desirability of

more frequent blowing. Drain the lines generously before blowing tubes. Wet steam in the soot blowers will cause the soot to cake and become difficult to remove. Use the soot blowers in the proper order; that is start by blowing the air heater and/or economizer, then the superheater, the generating bank and finally the economizer and/or air heater again. The order of blowing in the superheater and generating banks should follow the path of the gases. The gas path may be determined from the general arrangement drawing showing the position of baffles, if any.

Raise the air pressure when using the soot blowers. When using soot blowers in port or under low loads, be ready to relight the fires should they be blown out. To reduce corrosion leave the soot blower drains *open* when the soot blowers are not in use and see that air check valves are functioning. The scavenging air check valves admit air to the elements when not in use to prevent corrosive gases from backing up into the soot blower heads and piping.

Hard external deposits found on economizer surfaces are evidence that either wet steam is being used for soot blowing or the temperature of the stack gases has fallen below the dew point. When the stack temperature falls below the dew point, there is danger of certain components of the stack gases condensing on the elements. These condensed gases, particularly those from fuels with a high sulfur content, will cause hard caking of soot deposits and are highly corrosive.

These hard soot deposits may plug the economizers, and cause corrosion damage. These deposits may be removed by steam lancing. Steam lancing ports are installed on most boilers.

On boilers equipped with air heaters, the by-pass must be used under low load conditions when the stack temperature may fall below the dew point. Failure to use the by-pass may result in soot caking and corrosion damage to the heating surfaces and uptakes. The accumulated soot may also result in a soot fire, causing severe damage to air heater.

Remove atomizers from the boiler when they are not in use. Atomizers in a cold boiler could flood the furnace with oil due to leaky valves. Atomizers not in use but remaining in position in a steaming boiler will become choked with carbon and may be damaged by overheating.

Inspect the fires for flame impingement on the refractory throats or floor where deposits may be formed.

Safety valves should be occasionally lifted manually as a check on their operation.

### EMERGENCY PROCEDURES

(Section 2-4)

#### Low Water

Low water, whether resulting from inattention, feed pump failure or any other cause, is the most serious condition encountered. If the loss is gradual and noticed by the operators:

- (a) Increase the rate of feed.
- (b) Check feed line for leaks or open valves.
- (c) Check blow valves for leaks or open valves.
- (d) Check auxiliaries for water in steam from auxiliary steam line which indicates leakage from boiler steam drum into desuperheater.
- (e) Start auxiliary feed system.

If, *at any time*, the water level falls out of sight in gage glass *secure all burners immediately*. *Caution.* Do not fill hot boiler with cold water, as relatively cold feedwater coming in contact with an overheated drum or tubes may cause severe distortion and leakage of rolled joints.

#### Tube Failure

In the event of tube failure, the boiler should be secured quickly except for the feed. Feedwater should be added in an effort to keep the water in sight until the boiler cools down. *Watch the water in the other boilers.* The sudden demand for feed may result in low water in the other boilers. If the failure is severe and the water cannot be kept in sight, shut off the feed to the effected boiler immediately. In extreme cases it may be necessary to keep the forced draft fan running to carry the steam up the stack. If escaping steam is a danger to life the boiler may be emptied through the bottom blow.

#### Loss of Fires

If the burners should go out from loss of oil pressure, stoppage of the pump, forced draft blower failure or water in the fuel, close all burner valves immediately, ventilate the furnace and relight burners one at a time using a torch. Restoring the oil supply with the burner valves open and

allowing the fires to relight from hot brickwork may result in an explosion.

### Air Heater Fires

Air heater fires can be avoided by keeping the heating surfaces clean. In the event of fire, considerable damage is usually done by the time the fire is detected. The boiler should be secured, shutting down the forced draft fan quickly and using the steam soot blowers in the air heater as an aid in smothering the fire.

*If the boiler is shut down for any reason, open the superheater vent to maintain a steam flow through the superheater. Crack superheat drains to prevent accumulation of water in the superheater elements.*

### FUEL ECONOMY

(Section 2-5)

To obtain high boiler efficiencies, the following conditions should be observed:

Maintain operating temperature and pressure

Adjust burners for proper combustion

Keep fire and water sides of boiler clean

Check casings and all pressure parts against leakage.

The most common cause of low efficiency is excess air. A certain amount is necessary but it should be kept to a minimum. To obtain the proper amount of air, without smoke, burners must be clean and properly adjusted with the jacket tube so that the flame just clears the refractory cone without impingement. The best position may vary slightly with different firing rates. To obtain best operating results the jacket tube may be moved in and out by loosening the thumb screw for proper mixture of air and oil. The jacket tube should also be the proper length so that the face of the sprayer plate nut is in correct relation to the face of the diffuser. This varies with different types of burners; with the Todd "Vee-Cee" burners the face of the sprayer plate nut should project  $\frac{1}{2}$ " into the furnace beyond the point where the diffuser starts to flare. With Todd straight mechanical (Hex-Press) burners this distance is  $\frac{1}{4}$ ". Using the Vee-Cee steam assisted atomizer the distance is  $1\frac{1}{4}$ ". This length is altered by loosening the set screw and screwing the burner clamp on or off the jacket tube. These dimensions apply only with the Standard Hex-Press Register and Hex-Press diffuser.

The refractory cone must be concentric and have the proper depth and angle. The air registers should be in good order, that is, working freely, not warped or choked with carbon deposits.

The fuel should be at the right pressure and temperature for best atomization. Oil that is too cold will not atomize properly and oil that is too hot will carbonize in the burner tips. The best atomization of the fuel oil is generally obtained when the viscosity is 150 Seconds Saybolt Universal. The temperature at which the fuel will be at this viscosity may be found by referring to the chart, Fig. 1. Use the proper size sprayer plates. Make sure the tips you are using have the proper spray angle. *Do not use more than one size burner tip in the steam generator at the same time.* Use all burners unless oil pressure becomes too low. The use of steel tools in cleaning sprayer plates may damage them, resulting in poor atomization, thereby requiring a large amount of excess air to eliminate smoke. Enlargement of the holes will result in each burner handling a different quantity of oil and adjustment of proper amount of air will be impossible.

Excess air in large quantities will be indicated by white smoke. In some cases white smoke may result from too high fuel oil temperature. If the flame is intensely white as observed through peepholes in boiler or burner, too much air is being supplied. If the flame is red there is insufficient air. The ideal flame is a bright golden color. Excess air will also be indicated by a rise in superheat temperature but for accuracy the use of an Orsat to analyze the flue gases is necessary. Smokeless combustion or a very light brown haze with high  $\text{CO}_2$  (12.5% to 14%) and no CO are the ideal conditions.

Boiler casings must be tight as any air leaking into the boiler will sharply reduce efficiency.

Steady steaming with little fluctuation in air or oil pressures will be an advantage. Normal temperatures and pressures should be maintained. High stack temperatures may mean excess air or fouling of the heating surfaces. A rise in air pressure required for combustion may be caused by poor burner adjustment or partial plugging of the gas passages. Keep the firesides of the boiler clean, particularly the superheater and the economizer. Fouling of the heating surfaces not only reduces the heat transfer rate but in extreme

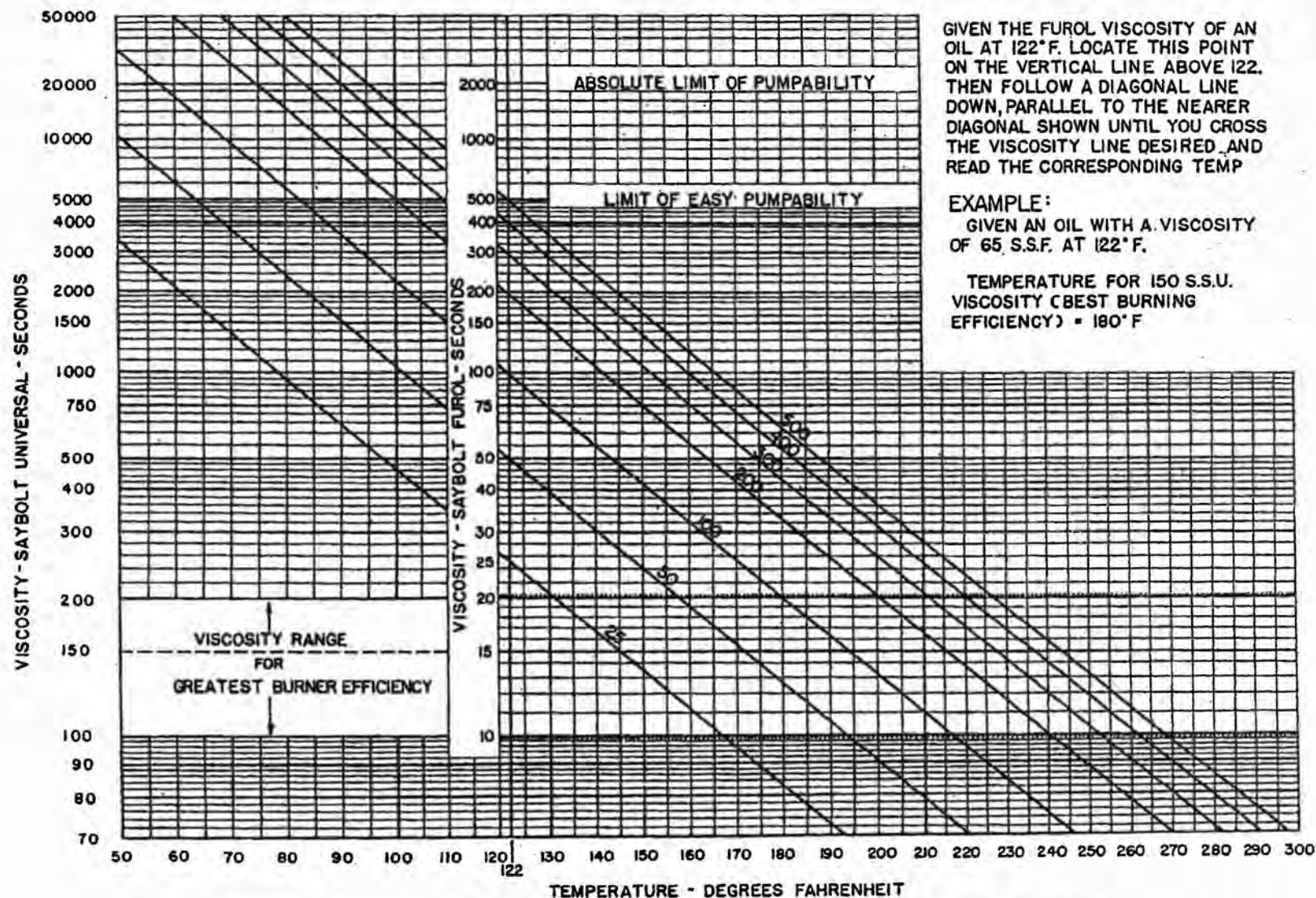


FIGURE 1. CHART FOR DETERMINING PROPER BURNER TEMPERATURE TO GIVE MOST EFFICIENT COMBUSTION.

cases "laneing" may result with high gas velocities and temperatures through small sections of the boiler. This causes severe damage to all parts adjacent to or within the lane. Frequency of use of the soot blowers should be governed by the changes in draft loss and stack temperatures before and after blowing tubes.

Maintain proper feedwater temperature. Lower feed temperature will result in higher superheat. Conversely a high feed temperature will cause superheat temperature to be below normal.

### **PUTTING NEW STEAM GENERATOR IN SERVICE**

(Section 2-6)

Before a new boiler, one that has been laid up or one which has undergone extensive repairs, is put in service it should be subjected to a hydrostatic test, boiling out, drying out for the refractory and final inspection.

#### **Hydrostatic Test**

Prepare the boiler for hydrostatic test by removing all tools, rags, etc. from the drums, tubes and headers. Many tube failures are due to negligence in removing foreign materials. Close up all handholes and manholes. Remove all access doors including those for waterwall headers. A boiler that has been in service must be thoroughly cleaned on the fireside to facilitate inspection. Check operation of pressure gages. Close tightly all stop check, drain and blowdown valves. Install blanks where necessary. Do not allow a stop valve with steam on one side to be subjected to hydrostatic test on the other side of the valve. Install safety valve gags. Do not use a wrench on these gags. It is unnecessary and may result in bent valve stems.

The vents on the drum, superheater and economizer should be open while filling the boiler to let the air escape. These vents may be closed as water issues from them. Some boilers have check valves in the feed line between the economizer and the drum. If the test pressure is being applied through a connection to the air cock on the boiler drum, a separate test will be necessary on the economizer. The boiler should be at room temperature before testing. The water used for the test should be at the same temperature or above. It may be

as high as 180 F. but in no case less than room temperature or less than 70 F. whichever is higher. In high pressure boilers with thick drums, it is desirable that the temperature of the water used for filling be close to the boiler temperature. The use of cold water for testing a boiler which has not thoroughly cooled down will result in leaking of the rolled joints.

The pressure should be raised gradually, being careful not to exceed the test pressure.

A hydrostatic test to the working pressure will usually be sufficient for a boiler which has been repaired but for a new boiler or one undergoing annual inspection the test pressure is  $1\frac{1}{2}$  times the design pressure.

When inspection of all pressure parts and rolled joints is complete the pressure may be lowered by cracking a drain valve. Open a vent valve before the pressure drops to zero and leave wide open while draining the water to avoid a vacuum on the boiler.

The desuperheater should be tested separately at a pressure not over 300 lb. A leaking desuperheater would allow water from the drum to pass into the desuperheater and be carried with the steam to the auxiliaries or superheater.

On completion of the test, drain all water from the superheater and desuperheater, remove safety valve gags, and remove any blanks.

#### **Boiling Out**

The boiler must be boiled out to remove any preservative on the tubes and the oil used in rolling the tubes. Oil is a good insulator and if any remains after erection or repairs, blistered and ruptured tubes may result.

Before proceeding with boiling out of boiler remove as much oil as possible by wiping out the ends of the tubes, the headers and drums using rags and by pulling rags through the tubes, using an approved solvent. Make sure no rags are left in the boiler as a tube may be plugged and the loss of circulation will result in tube failure. Air circulation should be provided for the protection of any men working inside the drum.

The boiling out solution consists of three pounds of caustic soda and three pounds of either soda ash or trisodium phosphate for each 1,000 pounds of water capacity of the boiler at normal water level

A-boiling out solution using five pounds of Navy standard boiler compound for each 1,000 pounds of water capacity is also satisfactory. The chemicals should be mixed thoroughly in hot water and the solution poured into the drum. Close up the drum and fill the boiler until the water is just in sight in the gage glass. The superheater vents and drains and the air cock should be open.

Observe all normal safety precautions when the boiler is being fired for drying out or boiling out.

Using the smallest size sprayer plate, fire the boiler, closing the air cock when steam issues from it but leaving a superheater vent open sufficiently to maintain a good steam flow through the superheater. Allow the pressure to rise to 50 pounds and maintain this pressure during the boiling out. Raise the water level nearly to the top of the glass and blow down the level to  $\frac{1}{4}$  glass using the bottom blow. Mix another ten pounds of boiling out solution and inject into the boiler using the chemical feed line. Every six hours again raise the water level and repeat the blowdown procedure. This should be continued for 36 hours or until examination of water samples from all blowdown lines shows that no oil is present. The sample, in a glass container, is best examined in a dark room by shining a small pen type flashlight through the water. Another simple test consists of dropping small shavings of camphor on the surface of a sample in a shallow container. If the camphor remains motionless, oil is present. If even the slightest trace of oil is present the boiling out process should be continued.

When boiling out is completed, the solution is preferably dumped overboard through the bottom blow. It is highly caustic and will cause damage to paint or protective coatings if dumped into the bilge. The compound may cause some damage to valve stem packings and some repacking may be necessary. Also, gage glass mica may require replacement because of contact with a caustic solution. After the boiler is emptied it should be opened up and all tubes and headers thoroughly washed out with a high pressure fresh water hose.

### **Boiling Out Pressure Parts by Steam Method**

If steam is available and the pressure parts are to be boiled out but the furnace is not to be dried out, attach steam supply lines to the bottom blow

valve and the lowest openings in the superheater and economizer. If practicable, blank off the piping connection between the steam drum and the superheater and also the piping between the steam drum and the economizer. Close all other openings and provide independent blowdown lines from the steam drum, superheater vents and economizer vents.

Using just enough water to dissolve the compound and soda, make up separate boiling out solutions for the boiler, economizer and superheater, by dissolving three (3) pounds each of soda ash and caustic soda (or 5 lb. of Navy standard boiler compound) for each 1,000 lb. of water capacity of each of these sections.

Using a portable or hand pump, inject the boiling-out mixtures into the generating, superheater, and economizer sections of the boiler. The mixture for the generating sections should be divided between the water drums and headers. Add fresh water to the *generating section only* to bring the water level in sight at the lowest visible point in the boiler water-gage glass. The mixed compound should be admitted to superheaters and economizers without additional water.

Admit saturated steam to the boiler, superheater and economizer maintaining a pressure of 25 to 50 lb./sq. in. in the steam drum. To insure circulation, the steam supply should be under a pressure of about 25 lb./sq. in. higher than the pressure in the steam drum. Open the steam drum, superheater and economizer vents to permit a continuous slow overflow from each section. Boil out the pressure parts in this manner for 24 hours; then shut off the steam supply and drain the superheater, economizer and boiler. Flush the superheater, economizer and boiler either through the temporary blowdown lines or by filling the boiler and economizer and flooding the superheater.

Drain the boiler and wash out and inspect all pressure parts.

### **Drying Out Furnace**

A drying out fire should be lit in the furnace within a few hours after installing new plastic refractory. A wood fire is generally considered to be the best for this purpose as it provides a more even heat for the entire furnace. The boiler should be prepared for lighting off in the usual manner as

## OPERATION

if getting ready for steaming except that a wood fire is started in the center of the furnace floor. The fire should be kept burning at least 18 hours and longer if time allows. The longer the drying out period, the better. If the setting is heated too rapidly, the outer layer of refractory will dry first, shrink away from the remainder and cracks will result. Also, with rapid heating, steam formed in the refractory, especially in a thick wall, may not be able to seep out without developing pressure. Do not allow the steam pressure to exceed 100 lbs. during this period. Removal of an air register allows more wood to be added.

The furnace may also be dried out with an intermittent oil fire using the smallest size sprayer plate and rotating the fire from one burner to another every half hour. The pressure should not be allowed to exceed 100 lb. Drying out may be completed in a minimum of 12 hours, although 24 or 36 hours is more desirable. At the end of this time the pressure may be raised to working pressure and the boiler cut in on the line if necessary. The furnace will be dried out but 12 to 24 hours of steaming at normal capacity is required to cure the refractory. If the boiler is to be cooled down again, close all openings and allow to cool slowly. If possible, enter the furnace to check the drying out and look for cracks or excessive shrinkage.

Drying out may be accomplished simultaneously with the boiling out process if the initial firing rate is kept very low and increased slowly.

### Inspection

Because of the possible presence of inflammable or noxious vapors in the steam generator, it is extremely important to ventilate the unit thoroughly before entering for inspection of pressure parts. It is also important to make sure, before entering the unit, that all valves which might permit the entrance of steam or water are tagged, closed and secured by a lock or wiring.

Make a thorough inspection of the internal surfaces and, if any scum or oil is present, repeat the boiling-out procedure. It is advisable to run a rag on a rod through various tubes to determine their condition. Black smudge may be found at the ends of a tube in a new steam generator even though the remainder of the tube may be clean. A slight trace of this black deposit is not harmful and it may be wiped out with a rag which has

been moistened with a non-oily, non-poisonous cleaning fluid; however, if the black smudge is greasy or if any other oil or grease is found, it will be necessary to boil out the pressure parts again.

Before closing up the drum, check the internals including baffles, chemical feed line and regulator damping chamber to see that they are secure and that holes are not clogged. On a boiler that has been in service examine for scale deposits and corrosion. Pitting of the drum at the waterline or above is usually a sign of oxygen in the feedwater. Also examine the desuperheater and the feed line applying hydrostatic test if necessary to check tightness. Check dry pipe making sure holes or slots are not plugged.

The internal surfaces of the superheater tubes should be inspected for scale deposits. Scale indicates carryover and will quickly result in a warped superheater and tube failures.

When examining the fireside, the soot blowers should be rotated from the outside. Check alignment of the holes so that steam will not impinge on the tubes, and also that the soot blower elements are straight and not chafing on the tubes. Elements may be straight but the boiler tubes warped so that chafing occurs.

On a boiler that has been in service, check for blistered or sagged tubes. Look for soot deposits in the air heater, economizer, economizer vestibules and the superheater bank. Examine the soot blower bearings, edges of the superheater support plates, access doors and openings for corrosion. See that baffles are secure and dampers operating. Inspect refractory to see that headers, drums, doors, doors frames, etc. are adequately protected. Measure the thickness of the brick wall to determine if erosion necessitates renewal. Determine the depth of the floor by measuring from the top of the floor to the centerline of the burner. If the floor is too high because of slag deposits it should be renewed as flame impingement will build up more carbon deposits.

Encrustations around handholes indicate leaks. Gaskets or ferrules should be replaced and encrustations removed as they are corrosive.

Examine the air casings under the burners for oil which may be a fire hazard.

Before closing up and filling the boiler, be sure the bottom blow valve is closed.

### Initial Starting

Before starting a new boiler for the first time, make sure all gages, thermometers and test connections have been installed and are operating. Check all auxiliary equipment such as feedwater regulators and indicators, valves, combustion control system and soot blowers. Read carefully the sections under "Operation" and "Operating Precautions". Before cutting in the boiler it is imperative that the safety valves be blown and reset, if necessary, to lift at the proper pressures. The superheater safety valve *must* lift before the main safety valves to give adequate protection to the superheater.

It is desirable to limit the firing rate to low loads for a few days to thoroughly dry out and cure the refractory and also to ascertain that all auxiliary equipment functions properly.

### LAYING UP BOILERS

(Section 2-7)

A boiler not in use should not be allowed to stand partially filled with water for long periods. If it is expected that the boiler will be out of service for more than a day, fill the boiler, economizer and superheater completely with water to give protection against corrosion. Care should be taken to see that the boiler is *completely* filled by building up 20 or 30 lb. pressure and venting at high points. Make sure that leaking valves do not allow the gradual entrance of steam or feedwater from other boilers, as serious corrosion will result.

To fill the boiler, deaerated feedwater should be used, adding chemicals to give a final boiler alkalinity of 20 to 30 gr. per gallon. This should be

checked occasionally as the alkalinity will gradually decrease. Either provide means for recirculating the feed water when filling or add sufficient soda ash or caustic soda before the boiler is filled. Adding these later with no circulation may result in spots of concentrated alkalinity. If possible, light a fire under the boiler before it is completely filled to circulate the chemicals and drive off any oxygen. The filling of the boiler and the superheater may then be completed. Do not use the wet lay-up method if danger of freezing exists. Be sure the superheater is drained before putting the boiler in service again.

If the boiler is to be laid up for a prolonged period it is best laid up using one of the commercial preservatives available to coat all internal surfaces or else it may be laid up dry. If laid up dry it is important that it be drained completely, using an air hose to blow water out of any pockets that are not self draining and mopping up water remaining in the drums. Check all valves for tightness. A number of shallow pans containing a dehydrating agent such as silica gel, quicklime or calcium chloride should be placed in each drum and the boiler closed up tightly. This dehydrating agent should be examined every 3 months and replaced whenever it has absorbed enough moisture to make it ineffective.

Before laying up a boiler it should be thoroughly cleaned on the fireside. Soot deposits, especially when damp, are highly corrosive and if allowed to remain may result in serious damage to the casings and pressure parts. All openings to the furnace should be tightly closed and the stack covered. Better protection may be had with special fireside preservatives sprayed on the tubes.

## BOILER FEED WATER

### BOILER FEED WATER

(Section 2-8)

#### Sea Water Distillate

Practically all waters used for boiler feed purposes contain some impurities which are undesirable. The distillate obtained from evaporation of sea water should not contain more than 0.5 grain per gal. of chloride. Even then small amounts of all the other salts found in sea water will be found in the distilled water and eventually will enter the boiler with the make-up feed water. The soap hardness of water distilled from sea water normally will show less than 0.3 grain per gal. of hardness when the chloride content is not over 0.5 grain per gal.

#### Shore Water

All shore waters contain varying amount of contaminating salts, depending on the character of the rocks, sand, and earth over which they have flowed and on the extent and nature of municipal treatment to which they have been subjected. The impurity content of shore water will always be higher and, more important, will be chemically and proportionately different from that of the evaporated water which water-treatment is designed to control. Water received from shore should not be used in the boilers (except in emergency) without first being evaporated in the ship's distilling plant. If necessary to use shore water without distillation, the water should be tested and only a neutral water, low in hardness, should be accepted for temporary use during the emergency. A neutral water is one which is colorless with phenolphthalein indicator and green with methyl-purple indicator. The evaporation of shore water, in order to obtain satisfactory feed water for the boilers, may result in depositing on the evaporator tubes an extremely hard scale different from that resulting from evaporation of sea water.

#### Salt-Water Contamination

Feed water shall be maintained as free from impurities as possible. This requirement involves careful attention to the entire plant through which the water passes, either in the form of steam or as water, for, even though water used as make-up feed be excellent at the time of its entry into the system, it may absorb impurities from the various parts of the installation.

The most common source of contamination of the water in boilers is salt-water leakage into the fresh-water system. The principal parts of the system where this leakage may occur are listed below:

- (1) Condensers: main, auxiliary, and dynamo.
- (2) Salt-water-cooled air-ejector condensers.
- (3) Distilling plants.
- (4) Salt-water-cooled gland-exhaust condensers.
- (5) Leaky bottom-blow valves on idle boilers.
- (6) Leaky feed suction and drain lines which run through bilges.
- (7) Leaky seams and rivets in reserve feed tanks.

#### Condensate Leakage

Condensers are the most common source of salt-water leakage into the feed water system. Particular attention should be given to establishing a routine to detect leakage of salt water into the fresh-water side of condensers. In most installations, the condensate consistently contains no more than 0.5 grain per gal. of chloride. Any consistent increase above this value is a definite indication of a leak. When a leak is detected, it should be corrected as soon as operating conditions will permit dismantling the unit affected.

#### Effect of Condensate Carry-Over

Whenever the condensate from any condenser shows the presence of chloride to be above the usual operating value, it is well to check the steam from the boilers by testing a sample of water from one of the steam drain lines. Such a steam-condensate sample should be tested for both alkalinity and chloride since a small amount of alkalinity may affect the chloride determination. The results of the steam-condensate analyses will indicate whether or not there is any carry-over of boiler water in sufficient quantity to give more than normal chloride readings in the condensate. Sudden large increases in ship speed may cause carry-over from the boilers. The effect of this carry-over on the chloride in the condensate will be more pronounced the higher the chloride content of the boiler water.

### Source of Contamination

It is of the greatest importance that any unusual rise in the chloride content in the feed tanks, feed water, or boilers be investigated at once and the source of the leakage found and corrected. To locate these sources, test the fresh water from different units in the system, and where possible cut out the elements one at a time until the feed water freshens. A test for chloride in the feed water should be made each time one of the elements is cut out. Before making a test, the plant should be allowed to operate for several minutes without this element in commission so that the chloride concentration of the feed water due to that element may have time to be diluted with salt-free water.

### Leaking Lines in Bilges

The system may be salted up by leaky feed-suction lines which run through the bilges. Such leaks will also be responsible for some loss of make-up feed water. Periodic tests of feed-suction lines should be made as very often leaks will exist which are responsible not only for a loss of fresh water but for loss of pumping efficiency when the lines are being used.

### Elimination of Air in Feed Water

It is imperative that all possible precautions be taken to eliminate dissolved air from the boiler feed water in order to reduce corrosion of boilers and, particularly, of economizers. Elimination consists in correcting all possible sources of air leakage into the feed system and of maintaining the efficiency of the deaerating equipment. Where open hot wells are used, it is recommended to keep temperature as close to 212 deg. F. as possible, so as not to absorb air from the atmosphere. This can be accomplished by the installation of a small heating coil in the hot well. The hot well should be tightly covered, with a minimum opening for observation.

### Elimination of Oil and Grease

The presence of oil and grease in the feed water and in the boilers is a frequent occurrence. The following precautions should be effective in preventing any oil from reaching the boilers:

(1) In general, it is not necessary to use oil for the internal lubrication of the steam cylinders or valve chests of any reciprocating machinery. Saturated steam provides enough water of condensation to give the necessary lubrication, and in superheated steam units the metals used are usually designed to operate satisfactorily without lubrication. The use of a pure mineral oil may be used in special cases. Only a light, smooth coating of petrolatum shall be applied to the inside of cylinders at specified inspections.

(2) Very little lubrication of rods is necessary and this lubrication shall be kept at a minimum by the use of small quantities of mineral oil at each application. With main reciprocating engines using forced lubrication, the oil from such parts as crossheads and guides should be prevented from splashing on the piston rods or valve stems.

(3) When filters or grease extractors are fitted, they always should be used and kept in efficient condition.

(4) Filtering material should be cleaned or renewed as often as found necessary. Special precautions and instructions when using diatomaceous-earth filter-aid should be observed.

(5) Drains from fuel oil heaters and from heating coils in lubricating oil tanks and fuel oil tanks always shall be passed through an inspection tank before discharging into the feed system. Frequent inspections of these tanks are necessary in order that the presence of oil will be discovered soon after its first appearance, in order that drains may be diverted to the bilge until the source of contamination is removed.

### Avoid Excessive Make-Up

It is necessary to add to the system make-up feed water to replace water lost by leakage. All boilers, piping, glands, and valves should be kept tight and in efficient condition. The amount of make-up feed used per hour in port and per mile under way should be checked daily and every effort made to keep these amounts at a low and consistent level. The use of excessive quantities of make-up feed indicates lack of attention to one of the most important details connected with operating the engineering plant of a vessel. The amount of make-up feed water used by a ship is usually a fair indication of the overall engineering efficiency.

## BOILER FEED WATER

**Boiler-Water Hardness**

The occurrence of boiler-water hardness usually is evidence either that the make-up feed water contains excessive hardness or that the boiler contains considerable scale, although false soap hardness may result from the presence of zinc supplied either by condenser corrosion or from galvanized storage tanks. The amount of compound which is added to maintain the proper alkalinity should simultaneously insure zero hardness of the boiler water if proper feed water is used. The source of any unusual hardness in the boiler or feed water should be searched for, found, and corrected. If the boiler water consistently shows hardness, and the measures taken fail to remedy this condition, competent feedwater treatment concern should be consulted.

**Securing Boiler Water Samples For Analysis**

When taking water samples for analyses, it is particularly important that the sampling connection first be thoroughly flushed to insure obtaining samples that are truly representative of the water in the boiler and to remove sediment which may be trapped in the connection. Coolers should be installed in the line from the connection with the Salinometer valve to cool the boiler-water samples to approximately 100° F. except that samples for dissolved oxygen test must be cooled below

70° F. Figure 2 shows a typical cooler. Samples of water for analysis should be taken in clean containers, should be free from suspended matter, and should be protected from contamination during the time between sampling and analysis. If the sample bottle is not stoppered tight, alkaline samples will absorb carbon dioxide from the atmosphere reconvert the hydroxide to carbonate, so that erroneously low results for alkalinity will be obtained with the phenolphthalein titration.

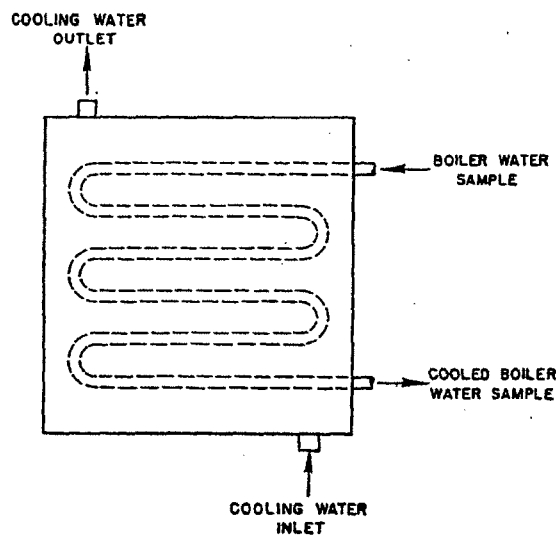


FIGURE 2. SUGGESTED METHOD OF COOLING BOILER WATER SAMPLES FROM SALINOMETER CONNECTION.

## Part III — MAINTENANCE

### BOILER AND WATERWALL

(Section 3-1)

The most important item in the care of boiler tubes is to keep them clean inside and out. The outside is kept clean by the use of soot blowers and the inside by careful attention to the water treatment. It is recommended the tubes be turbed throughout with soft wire brush as often as is found necessary. The tubes nearest the furnace will require the most cleaning as they are exposed to the highest gas temperatures, and consequently scale has the greatest tendency to form in them.

The firesides of a boiler present more of a problem. Soot accumulations are removed with the soot blowers and, periodically, by removing the access doors and hand lancing and scraping. For deposits of soot and slag that resist these methods the operator may resort to water washing.

### WATER WASHING

(Section 3-2)

When gas passages have been clogged to such an extent that mechanical cleaning is ineffective, the firesides should be cleaned by hot-water washing. This procedure should not be used indiscriminately and is ordinarily necessary only for inaccessible superheaters and economizers. The following should be kept in mind when resorting to water washing:

- (1) Possibility of damage to brickwork
- (2) Possibility of acid corrosion of tubes and drums
- (3) Availability of sufficient fresh water
- (4) Protection of electrical equipment around or under the boiler. *Boilers shall be dried out carefully immediately after water washing.*
- (5) Because of damage caused by water washing, it should be resorted to only when all other methods have failed.

### Methods

In general, there are two approved procedures for water washing:

- (1) Use of a water lance, see Fig. 1.
- (2) Use of soot blowers for distributing the water in the tube nests.

The first method requires less water and results in less wetting of the boiler and refractories but has the disadvantage that all parts of the tube nests cannot be reached. The second method requires more water and results in considerable wetting of the boiler but has the advantage of the washing action of a large quantity of water. When sufficient water is available, best results can be attained by employing a combination of the two methods. The procedure described below involves the use of both methods. When necessary to conserve water, use the lance method. The latter will ordinarily be found sufficient for economizers and (when necessary to wash) the generating, waterwall, and water screen tube banks.

### Procedure

Open, remove, or loosen access doors and panels to provide access to the firesides and drainage from the furnace, and around drums and headers. It may be found desirable only to loosen certain panels to reduce splashing on adjacent machinery or personnel. Line up a fire and bilge pump for pumping the waste water overboard.

Install canvas shields or gutters where practicable to reduce wetting of the refractories or

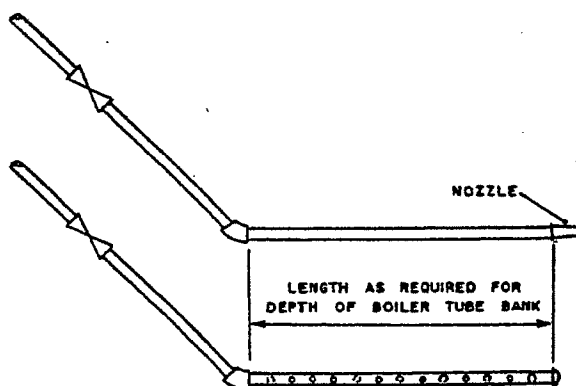


FIGURE 1. WATER LANCE FOR APPLYING WATER LOCALLY WHEN WATER WASHING.

## TUBE REMOVAL &amp; REPLACEMENT

## TUBE REMOVAL AND REPLACEMENT

(Section 3-3)

Screen, waterwall, roof and floor tubes, or any tubes in or near the furnace and superheater tubes, may be plugged in case of failure, but should be replaced at the first opportunity.

When plugging tubes on the fire side of the furnace, the following factors should be taken into consideration:

(1) *Screen tubes*—plugging or removal of these tubes will tend to increase superheat temperature.

(2) *Wall tubes*—removal or plugging of adjacent side, rear or roof tubes endangers the refractories.

(3) *Floor tubes*—plugging or removal of floor tubes should be held at an absolute minimum, since loss of these tubes will effect the circulation in the furnace wall tubes.

(4) *Superheater*—plugging or removing superheater tubes will increase pressure drop through the superheater, therefore, the number of tubes out of use in any one pass should be held at a minimum.

Tubes in the main tube bank may be plugged in case of failure. Because of the large number of generating tubes in the main tube bank, the loss of several tubes will not effect the performance of the steam generator.

**Boiler Tubes**

If it should become necessary to renew a boiler tube, the defective tube is removed as follows:

1. Working from the inside of the drum (steam or water drum) use a round nose chisel and chip off flare (sometimes called the bell) of the tube to be removed, until the tube end becomes flush with the drum. *Extreme care must be exercised in this operation so as not to dig the chisel into the drum.*

2. Use an acetylene torch or any heating torch, heat the inside of the tube to a dull red. Allow tube to air cool.

3. Burn, chip, or hack saw both ends of the tube at furnace side approximately 1" to 2" from tube sheets, taking care not to harm tube sheets. After both ends of the tube have been cut from the drums, the tube is pulled out through the tube bank and removed from the furnace. Boiler tubes located in the front of the superheater are removed through the burner opening. Tubes lo-

cated in the main tube bank are removed through the access door placed at the bottom of the casing.

4. Insert driving tool (made up to correct size and gage of tube) into the tube and drive the tool with a small mall. This will free the tube ends from the drums.

5. To remove tube ends without cutting flares off as above paragraph 1 describes, flush cut tubes next to drums on fire side and drive into drums.

When installing a new tube, first properly clean the tube seat to the bare metal using a fine emery cloth. Inspect the seat to check that no spirals or grooves remain in the tube seat.

The spare tubes may be protected with an internal coating which, if not removed, will act the same as scale in service. This should be thoroughly removed and the outside as well as inside of the tube at the ends must be free of burs and cleaned bright with fine emery cloth.

The tube is then placed in the drum holes and rolled with the proper expander for the tube size, gage and sheet thickness.

To remove waterwall tubes, follow instructions in paragraphs 2, 4 and 5, substituting the word "headers" for "drums".

The amount a tube should be expanded can only be determined from experience.

Tubes should be cleaned internally after expanding.

**Superheaters**

To cut out a superheater tube, first remove the handhole plugs from the header opposite the ends of the tube to be removed. Access to the superheater header is by means of panels or doors in the boiler casing.

Remove the adjacent plugs above or below this point to admit a light and to give better access for working. The tube should be cut at the U-bend end and one side taken out at a time. Use an acetylene torch and heat the tube end to be removed to a dull red. Allow the tube to air cool for shrinking. The bell end of the tube being removed is to be crimped in or cut off. Insert tube driver (made up to correct size and gage of tube) into the tube and drive the tool with a small mall. Pull tube at the U-bend end with a turn buckle or small chain hoist, taking up slack on turn buckle

## EXPANDING TUBES

**Step 1:** Cut the superheater element at the U-bend end removing U-bend in order to take out one side at a time. Assemble cutter shank extensions and insert through tube from the U-bend end. Attach pilot from hand hole end that fits nearest ID of expanded tube and attach weld removing cutter. Assemble sleeve, feed nut and washer over driving shank and screw into extension. Insert spacer and additional pipe spacer as necessary between sleeve and end of tube. With the use of an air motor or electric drill to turn driving shank, feed cutter by backing feed nut until weld is removed (approximately 1/16").

**Step 2:** Remove spacer. Back entire mechanism into header, replace cutter with tube removing reamer and proceed as in Step 1, until tube is entirely free from header. When reamer has penetrated tube for above 1/2", remove the pilot and continue reaming. Clean tube seat thoroughly of any particles of tube, paying special attention to the grooves.

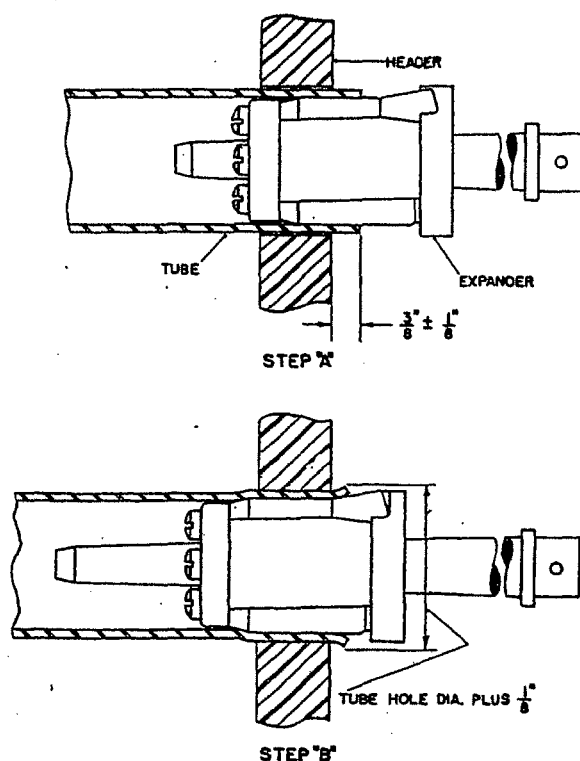


FIGURE 4. EXPANDER FOR ROLLING TUBES IN MAIN BOILER TUBE BANK AND THE SUPERHEATER ELEMENTS.

**Step 3:** Insert new tube to within 1/16" from inside face of header. Expand tube in seat by using expander with mandrels, universal joint and extension.

**Step 4:** Seal weld tubes as per instructions on arrangement drawing of superheater.

**Step 5:** Remove any weld splatter projecting over inside edge of tube or inside of tube.

## EXPANDING TUBES

(Section 3-4)

The proper use of expanders is of utmost importance in the installation of tubes. The process of expanding is a most severe application of power and unless care is used, tubes and tube seats can be badly damaged.

Tubes should be expanded just enough to secure tightness so that ample "life" may be left in the metal for future expanding should it be found necessary. The judgment of the operator must govern the proper amount of rolling.

## Description of Expanders

An expander consists of three or five expanding rolls and one or two belling rolls, held in place by a cage. A tapered mandrel fits thru a hole in the center of the cage. The rolls are set at an angle to the longitudinal axis of the body so that when the mandrel is rotated in a clockwise direction, it provides the pull or feed necessary to move the mandrel forward. As the mandrel moves forward, the rolls are forced outward expanding the tube to its seat.

The rolls are tapered to match the taper on the mandrel, so that they will expand the tube parallel to the seat. Selection of the proper expander to be used is important. Factors governing the selection include size and gage of the tube and the thickness of the seat in the drum or header. Composition of the tube, wall thickness and diameter may also affect the selection of the proper taper. Less

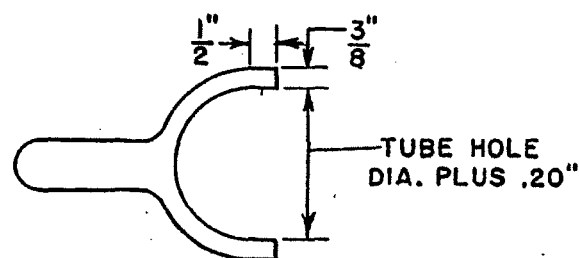


FIGURE 5. SNAP GAGE.

off the end of a tube from the expanding operation, it cannot get into a tube seat into which a tube has not been expanded.

When starting to expand a tube, the expander should be set into the tube, with approximate one-half of the straight rolls in the tube so that the expander will move into the tube as the mandrel is rotated. The proper setting can only be determined by experience as it is necessary to set the expander back farther from the end of the tube when expanding into a thick tube sheet than when expanding into a thin tube sheet. The expanding operation should be stopped when the small end of the belling roll is in line with the inside edge of the seat. If the tube has not been sufficiently expanded when the small end of the belling roll reaches the inside edge of the seat, the expander should be removed and the rolling operation repeated as outlined above. Do not let the small end of the belling roll pass the end of the seat as it will cut the tube, round the seat or pull the tube into the drum.

For starting to expand economizer tubes, the thrust collar should be set so that the distance from its seating surface to the front end of the

belling roll is the same as the distance from the handhole surface to the face of the tube sheet. When the expander is in place, it should be set so that the thrust collar is approximately  $\frac{1}{2}$ " to  $\frac{3}{4}$ " from the seating, that is  $\frac{1}{2}$ " to  $\frac{3}{4}$ " of travel left.

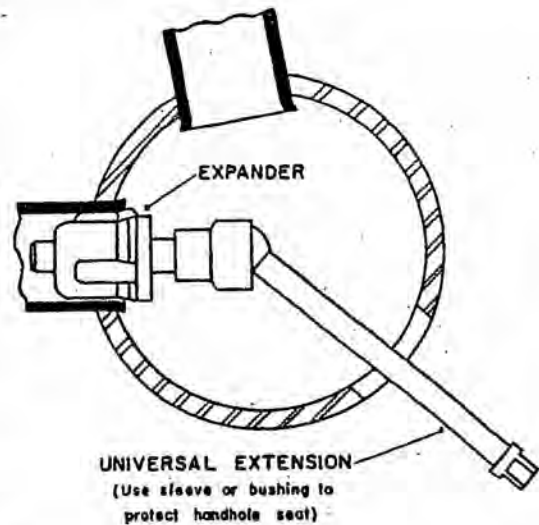


FIGURE 9. EXPANDER WITH UNIVERSAL JOINTED MANDREL FOR WATER WALL ROUND HEADERS.

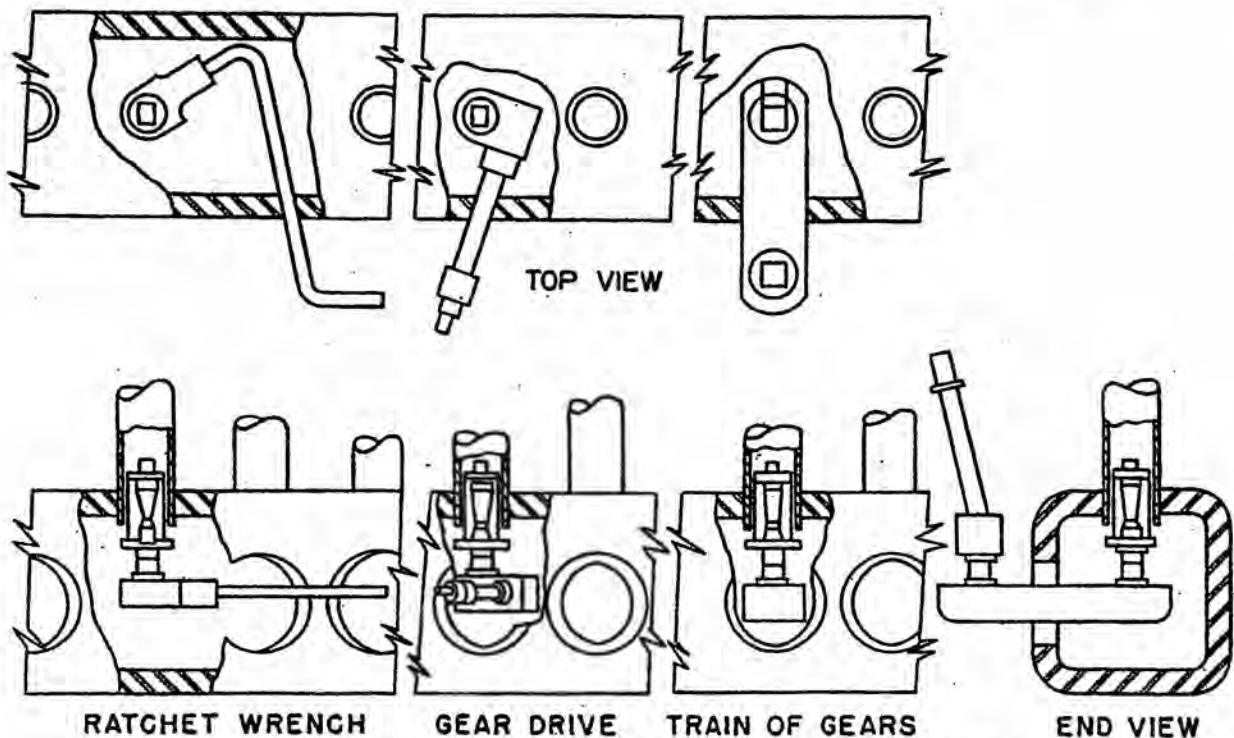


FIGURE 8. EXPANDING TUBES IN WATER HEADERS WITH HAND HOLES 90 DEG. FROM THE TUBE HOLES.

## HANDHOLE PLUGS

## INSTALLING AND REMOVING HANDHOLE PLUGS

(Section 3-5)

Check Drawing for types of handholes used on this installation.

Before installing handhole plugs, all plug seats, plugs and gaskets or ferrules should be carefully cleaned. Powdered graphite and water should be used on the threads of all plugs, to prevent the nuts from freezing after the equipment has been in service.

Particular care must be taken when reinstalling old plugs to see that all rust and scale is removed.

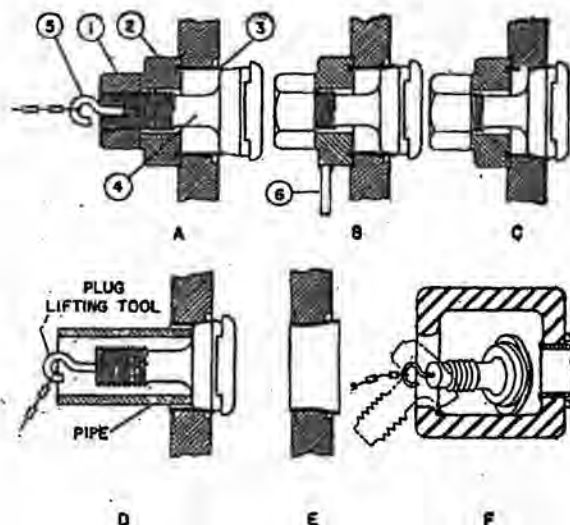


FIGURE 10. LIP TYPE HANDHOLE PLUG DETAILS.  
REFERENCE LIST

- |                      |                  |
|----------------------|------------------|
| 1. Nut               | 4. Handhole Plug |
| 2. Handhole Plate    | 5. Lifting Tool  |
| 3. Ferrule or Gasket | 6. Make-up Plate |

### To Install the Lip Type Plug

Screw the lifting tool into the end of the stud, pass the plug through the handhole and draw it squarely in against the header wall (see Fig. 10 above). Wipe both sides of the ferrule with light, clean machine oil and insert in hole. Keep the square edge of the ferrule outside and the beveled end against the plug.

Slip the make-up plate over the stud, making sure that the ferrule is entered in the grooved plate and is true and squarely seated on the plug.

Install nut hand tight as shown in "A" of Fig. 10. Hold make-up plate firmly against header and tighten nut with wrench, tapping the plate back against the header after each small increment of tightening. The plug must not be allowed to bind unless the plate is fully in contact with the header.

Draw the plug in as far as possible with the wrench, then remove make-up plate, coat stud with a water and graphite mixture and install the standard handhole plate and tighten nut securely. Note that the plug must be drawn in hard in order to compress the ferrule properly and make a sealed joint as shown in "C" of Fig. 10.

### To Install the Taper Plug (no lip)

Assemble the plug complete using make-up plate. Coat the threads on the handhole plug with a mixture of graphite and water and lightly coat both sides of the ferrule with clean, light machine oil. Keep the square edge of the ferrule outside and the bevel end against the plug.

Insert the plug into the seat and bring the make-up plate firmly against the header, similar to sketch "B" of Fig. 10. Slowly draw up the plug, using a wrench and tap the plate lightly to facilitate tightening and proper seating of the plug and ferrule.

When completely tightened and properly seated, remove make-up plate and replace with permanent handhole plate.

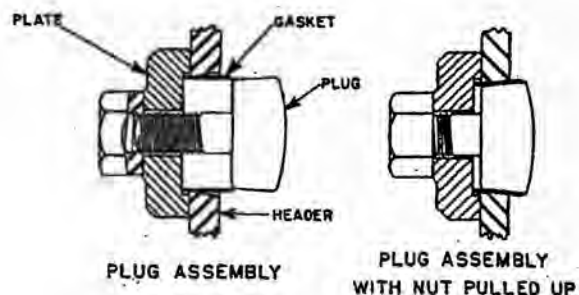


FIGURE 11. 2" STANDARD (STRAIGHT TAPER) HANDHOLE PLUG.

### Inspection

To remove plug for inspection, remove nut and plate and lightly crimp the projecting end of the gasket at two points to hold gasket in place. Next screw lifting tool into stud or fasten a wire around the stem of the plug, thread pipe nipple over

### ELLIPTICAL HANDHOLE SEAT GRINDER

For repairing minor defects in elliptical handholes, an Elliott Handhold Seat Grinder is suggested. This unit is designed to hold a grinding wheel in one plane while permitting its free movement in that plane. It is driven by either an air or electric motor, the drives being interchangeable.

The unit is set up for use by threading a face plate to a handhole plate stud of an adjacent handhole. An adjusting plate is screwed to the face plate on a ball joint, and adjusted by four leveling screws. This plate rigidly controls the alignment of the grinding wheel relative to the seat face. The grinder can be set up to work at any angle.

The width of the seat to be ground is controlled by a guide roller on the spindle housing, which bears against the side of the handhole. Guide rollers can be supplied in four diameters and four different diameters of grinding wheels are available. Adapters for  $\frac{3}{4}$ " and 1" handhold studs are furnished. A convenient spacer on the grinding spindle is used to adjust the level of the grinding wheel for various thickness of headers.

Handholes of any shape can be ground. Any handhole within range of the unit can be faced with a single setting. In case the reach is greater than 11 $\frac{1}{2}$ ", an extension link can be furnished.

### Operating Instructions

The handhole grinder is assembled with the grinding wheel ahead of the spindle collar for use in grinding heavy headers. For thin headers it will be necessary to assemble the spindle collar in front of the grinding wheel. Before setting up the grinder, measure the distance between the top of the header and the top of the yoke. This should be approximately 2 in. If it is less, use washers between the leveling plate and the top of the yoke. A good job of leveling the grinder reduces the grinding time and results in a smoother seat.

1. Remove the leveling plate from the grinder assemble by unthreading the ball nut.
2. In a handhole within reach of the grinder, assemble a handhole plate and yoke, then thread the leveling plate on the stud (plate has a 1" U. S. thread) and set up tight.

For other thread sizes of studs an adapter is used between the stud and leveling plate.

3. Insert the grinding wheel in the handhole to be refaced. Turn the adjusting lock nut clockwise to the limit of travel.
4. Assemble the grinder onto the leveling plate, adjust the grinder to the best working position and tighten the ball nut by hand.

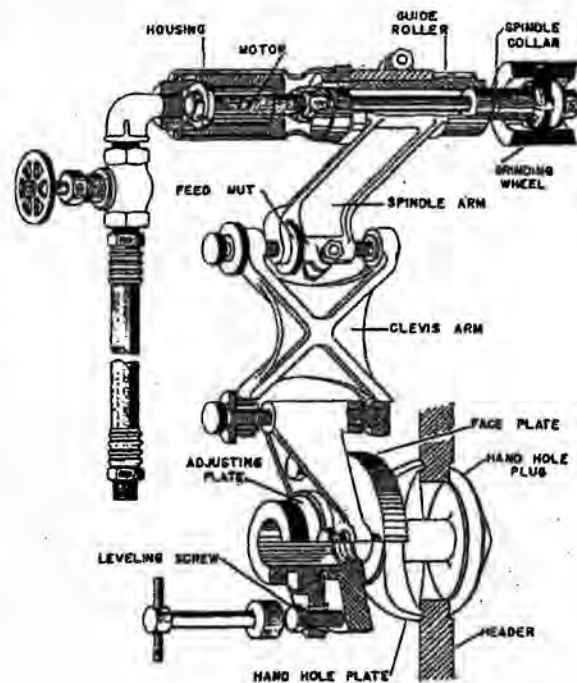


FIGURE 14. ASSEMBLY OF AIR-DRIVEN HANDHOLE SEAT GRINDER.

5. While turning the drive nut with the fingers, turn the adjusting lock nut counter-clockwise until the grinding wheel contacts the gasket face lightly.
6. Turn the adjusting screws, with the T-handle wrench, while twirling the drive nut, until the wheel contact is uniform around the entire seat.
7. Turn the adjusting lock nut clockwise to remove the grinding wheel from contact with the gasket seat.
8. Attach the motor drive unit by threading the motor onto the housing lock nut.

## HANDHOLE PLUGS

the handhole is out of round, it is advisable to true it up with a 5-roll expander.

For operation of the tool proceed as follows:

1. Measure the thickness of the header material in the handhole.
2. Measure the same distance on the handhole reseating tool, making adjustments by adding or subtracting some of the thrust washers, see Fig. 15 until the distance from the bottom spacer collar to the center of the rolls is such that when the tool is inserted in the header handhole, the bearing surface will fall approximately in the middle of the rolls.
3. Lubricate the rolls and the washers slightly.
4. Screw back the feed nut until the rolls fall back in the roller head.
5. Insert the reseating tool in the header handhole.
6. Tighten feed nut hand tight.
7. Place ratchet wrench on the end of the mandrel.
8. Drop latch so that it engages with the feed nut.

9. Rotate to the right approximately 45 deg.
10. Remove latch so as to stop feed.
11. Roll until tension is relieved.
12. Repeat steps No. 8 to 11 until a handhole seat of the required width is obtained, or until the marred surface of the header seat is refinished.

**Precautions**

1. The header surface where the spacer collar seats should be examined and must be perfectly true and at 90 deg. with the handhole opening.
2. Dimension for tapered seat as shown in Fig. 16 of handhole seat should be kept accurate, too wide a seat would make it difficult to make a tight joint.

**Caution**

3. Do not feed too rapidly and check continuously that latch feed does not slip into place, when rolling is commencing.
4. *This tool must be used with discretion; as over rolling or improper use may result in serious damage.*

## ECONOMIZERS

### Welded Return Bend Design

(Section 3-6)

#### Access Doors

Insulated access doors are installed at each end of the economizer. The doors at the rear of the economizer must be removed for access to the handhole plugs in the headers. These doors must be removed to examine welded joints for tightness. Doors at the front of the economizer, in addition to the above, are removed for tube removal and cleaning.

#### Internal Inspection

For internal inspection of the elements the hand-hole plate must be removed. Refer to Fig. 2.

- (1) Screw plug lifting tool into stud.
- (2) Remove nut, piece No. 7.
- (3) Remove plate, No. 6.
- (4) Slip pipe over lifting tool.
- (5) Drive plug into the header by tapping pipe as shown in view D of Figure 10 Section 3-5 Handhole Plugs (pg. 9).
- (6) Crimp ferrule (or gasket) part No. 8 Fig. 2 using crimping tool (Fig. 3) and remove from header.
- (7) Remove plug (5) by means of lifting tool.

#### Taking Economizer Element Out of Service

To take any element out of service, plug off the entire stream which is affected by it. Place tube plugs in the inlet (top) and outlet (bottom) headers of the elements of the lane in which the leak occurs—thereby blocking off the entire pass.

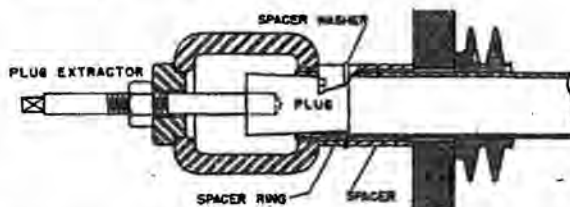


FIGURE 1. SECTION THROUGH FORGED STEEL HEADER SHOWING METHOD OF REMOVING THE PLUG FROM AN ECONOMIZER TUBE THAT HAS BEEN PLUGGED TO PERMIT OPERATION WITHOUT WAITING FOR REPAIRS.

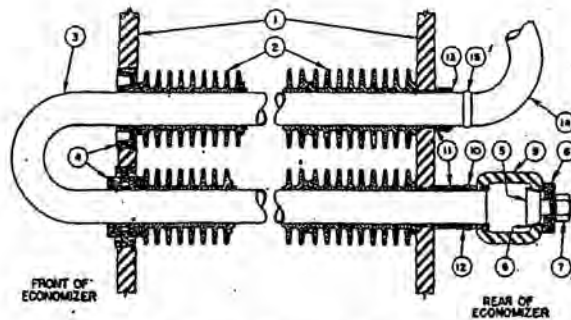


FIGURE 2. STANDARD U-BEND ECONOMIZER ELEMENT CONNECTED TO HEADERS WITH WELDED RETURN BENDS.

#### REFERENCE LIST

- |                           |                              |
|---------------------------|------------------------------|
| 1. Tube Sheets            | 9. Headers Inlet or Outlet   |
| 2. Extended Surface Rings | 10. Spacer Ring              |
| 3. Economizer Tubes       | 11. Spacers                  |
| 4. Sealing Rings          | 12. Spacer Washer            |
| 5. Hand Hole Plug         | 13. Tube Tack Weld to Spacer |
| 6. Hand Hole Plate        | 14. Return Bend              |
| 7. Nut                    | 15. Return Bend Weld         |
| 8. Ferrule or Gasket      |                              |

The flow of water through the individual passes of the economizer is shown by the drawing in Section 1—under "Description of Economizer" in the first section of this book. This drawing must be followed to determine the passes of water through the economizer. Carefully check the drawing to determine the pass in which leak occurs so that the elements at both the inlet and outlet header of this pass can be plugged.

The tube plug for this purpose should have a taper of  $\frac{1}{8}$ " in  $3\frac{1}{4}$ " length or  $15/32$ " per 12". The tube plug and plug extractor are shown in Figure 1.

#### Removing Economizer Elements

Burn, or preferably cut off (using hack saw) both return bends (14) Fig. 2 from effected element at four places where the return bends are welded. This cut should be made through the weld (15). This is necessary for accessibility in installing and aligning new element. Chip the tack weld (13) to spacer on effected element only. If one

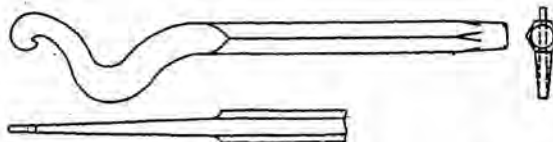


FIGURE 3. CRIMPING TOOL FOR REMOVING HANDHOLE GASKET.

## ECONOMIZERS

1. Thoroughly clean split chill ring and install it in the return bend. See Fig. 7.
2. Fit bend to tube and tack weld the tube in place.
3. Apply first weld head using  $\frac{1}{8}$ " Fleetweld #5 or #85 electrode.
4. Thoroughly clean the weld with a rotating wire brush or peen weld if more practicable.
5. Apply a sufficient number of welding passes

to build weld up flush with tube and bend. Clean each pass thoroughly as described above.

6. Apply a final weaving pass covering the weld.

After return bend is welded in place, tack weld tube to spacer in four places (Fig. 2, #13).

Replace handhole plugs and test the welded joints under pressure. If tight, replace economizer doors.

## REFRACTORIES

(Section 3-7)

### General Description

Why refractories and insulation?

The primary reasons for the use of materials of this nature are to confine the temperatures resultant from the combustion process in the desired areas, maintain uniform furnace temperature, to aid in supporting combustion and to protect vital parts of the steam generator from direct flame impingement or excessive heat.

For simplicity these materials can be divided into three groups according to their general characteristics and uses:

- A. Dense Fire Clay Refractories.  
(Super duty, special super duty or high heat duty.)
- B. Insulating Refractories.
- C. Industrial Insulating Materials  
(Block, Blankets, etc.)

(A) Dense Fire Clay Refractories may be subdivided into many types. This description covers only those materials common to Marine Steam Generator furnaces. Fundamentally the function of the dense fire clay refractories is to take the abuse or wear resulting from high furnace temperatures and direct exposure to gases of combustion.

Materials in this group are furnished in many different forms and shapes. Those common to marine boilers and generators are kiln fired fire brick, such as Empire, Mex-Ko and KX-99, the plastic and castable refractories such as Super Plastic, Super Hybond, Kast-Set and KS-4. The latter are of such nature that they can be molded or cast into desired shapes on the job. The KS-4 is a type of high temperature castable made especially for gun application.

Kiln fired fire brick are provided in standard and special shapes. The standard are referred to as series brick. These are designed to eliminate, to a great extent, undesirable cutting. Special shapes such as anchor brick, roof tiles, etc. are made for specific uses and locations.

(B) The Insulating refractories are refractories having outstanding insulating qualities. These

materials possess the property of insulating value at elevated temperatures. Their use will be covered later. Similar to the dense refractory group, these are provided in several forms and shapes, among which are standard shapes and castable types. An example of the latter is Kast-O-Lite, a lightweight refractory castable.

(C) Such items as block and blanket insulation, loose rock wool and insulating cement are identified as Industrial Insulating materials. Generally these materials are designed for high insulating efficiencies in a specific temperature range usually 1200° to 1900° F. These materials do not possess refractory properties and are therefore used as backing up and in areas where insulating efficiency more than refractory properties are desired. This group has in addition to pre-formed shapes such castable materials as castable #20, SK-7 and castable block mix which are used where it is necessary to form special shapes or fill hard-to-get-at areas. The SK-7 as in the case of KS-4 is made for gun application.

The materials described above are common to all Marine Steam Generators in part or as a whole.

### Refractories for Sectional Header Type Steam Generators

The materials used in the furnace and boiler sections of the sectional header boiler are largely of standard shapes and sizes. The walls are constructed with standard 9" straights and series brick of Mex-Ko super duty fire brick backed by insulating brick and/or block insulation.

Anchor brick secured by anchor bolts located on specified centers are provided to hold the wall back against the casings. All bricks are bonded together by a good grade of bonding mortar of the same characteristics as the clay used to manufacture the brick. In furnaces having water walls, i.e.: the Victory Ship boilers and the C2SAJ1 class vessels these tubes are backed up by a high heat duty fire brick such as Empire, backed by block insulation.

An illustration of typical side wall construction can be seen in figure 1. The application of materials in the floor and corbell in this type of unit is also illustrated in this figure. The materials used in the front wall and burner sections are shown in figure 2.

Corbell construction in these units serve a dual purpose. They are installed using Kast-Set or Super Plastic (as specified on boiler refractory drawing) to seal the floor expansion joints and to protect the wall headers from exposure to direct furnace heat.

The lower drum in these units is protected by a refractory wall, referred to as a bridgewall. This is constructed of either Super Plastic or Kast Set as specified. It is the practice to anchor these materials to the drum using special anchors made for this purpose. The top of this drum is protected by a covering of Kast Set.

Coal fired units of this type equipped with grates have a higher bridgewall than is common in oil fired units. This bridgewall is generally constructed of a slag resisting KX-99 fire brick to the height above the grate line as specified on brick work drawing. Either Super Plastic or Kast Set is then carried up from this point and over the top of the drum.

Furnace water walls in the "A" or "D" type units are backed with first quality or super duty refractories, i.e. Empire or if the latter Mex-Ko. Dependent upon the unit, these are either 9" straights and series or square edge tile. This is then backed with block and blanket insulation. The same construction is followed for the furnace roof.

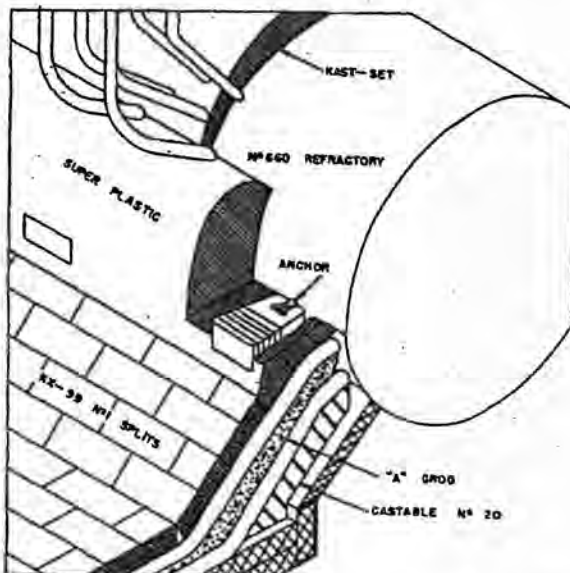


FIG. 3—REFRACTORY INSTALLED ON LOWER DRUM AND FLOOR TUBES OF "D" TYPE STEAM GENERATOR.

The economizer vestibule and boiler side and end walls are insulated in the same manner as described for the same area in the sectional header boiler. There are some exceptions to this, however. Some units have walls cast of Castable #20 insulation and others were equipped with special anchored square edge tiles. The vestibule floors are insulated with two layers of block insulation, the topmost covered with insulation coating to prevent penetration of water or soot into the block.

The superheater header is protected by a panel of Kast Set poured in place. This serves as protection from the hotter furnace gases that would cause damage to these headers and tubes. The casing on the loop end of the superheater is provided with removable access doors. These doors are protected with Kast-O-Lite backed with block insulation.

The refractory and insulating materials used in these units are designed to withstand the conditions normally expected to be found therein. With proper operation and maintenance, few if any, difficulties should arise.

### Causes of Refractory Failure

Some common refractory failures encountered in marine furnaces are spalling (mechanical, structural and thermal), slagging and abrasion. These are considered the major causes. Briefly the costliest refractory failures can be considered to be spalling and slagging. There are many factors that can be related to the causes of spalling for our purpose.

#### Spalling

Three basic types of spalling are:

1. Mechanical, sometimes referred to as pinching, is not frequently found to occur in furnace walls. This type of failure is generally caused by improper location or lack of proper expansion joints. Fireclay brick expand approximately 0.06 percent at 1800° F. It is therefore important that expansion joints be properly located, as shown on drawings.

2. Structural spalling is the type most frequently encountered in marine boiler furnaces. This condition is accelerated by slagging and flame impingement. Present day oils usually contain chemicals which act as a flux when deposited on incandescent fire brick. These fluxes have a

should be consulted. Discuss any problems that may arise with your service engineer.

After all old refractory, insulating materials and debris have been removed all casings and the floor pan should be examined for defects and distortions. It is important that these be repaired before replacing any brickwork or insulation.

In making renewals or repairs, emphasis should be placed on strict adherence to the boiler refractory drawing and any latest revisions suggested by your service engineer.

When laying fire brick care should be exercised to get thin even joints. This is accomplished by using mortar of a consistency suitable for dipping the brick. The best side of the brick should be selected for the furnace interior and after being dipped on two sides in the mortar, are then fitted snugly against the next by rubbing until a tight fit is assured. All joints should be staggered by placing a soap at the end of the course, or by the use of a large 9" straight. When placing the anchor bolts and anchor brick it is important that the fit be loose enough to permit movement due to expansion. During the construction of the wall all excessive mortar should be removed using a wire brush.

Whenever Super Plastic is to be installed, the manufacturers' recommendations should be followed closely. The plastic should be rammed in place using a three pound maul or an air rammer made for that purpose. Proper expansion joints should be provided and the plastic areas should be divided into sections with contraction cuts. These cuts are made by scoring the plastic approximately 3" deep with a sharp thin instrument such as a trowel. After completion of the Super Plastic work, the surface should be scratched to permit venting. When using Hybond, it is necessary to vent the surface by punching holes using a thin rod.

All castable should be dry mixed in a clean container before adding the water as prescribed by the manufacturer. Where metal tubes penetrate into or through the castable or whenever the castable is anchored with metal anchors, provision should be made for expansion of the metal within the castable. Wrapping with friction tape or some other combustible material will serve this purpose.

Firebrick used in the floor should be laid with staggered joints around the floor. Placing soft block insulation of 1" thickness in the expansion joints will provide a 1/2" joint free from debris.

If the boilers are to be water washed it is important not to substitute your insulating products with some which are soluble in water, as there is a danger of washing away the backing up insulating materials. Wherever possible, water should be diverted away from the furnace and boiler linings.

On repairs where Plastic refractories are to be used, these materials should be applied last. It is desirable to light off as soon as possible after this work is completed. Where castables have been used the opposite will apply as the castables become stronger if permitted to fully air set before the application of heat.

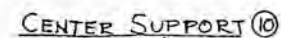
When all work has been completed, and all safety precautions have been complied with, a slow fire (wood if possible) should be started. If the unit is oil fired the smallest tip possible should be used. This drying out or baking period will permit the moisture to escape without building up captive steam in pockets throughout the lining. It is advantageous to maintain this fire for 18 to 24 hours if possible. The temperature may be gradually increased until steam is raised.

Patching or minor repairs to the furnace or boiler linings should be made as soon as discovered. This procedure will prevent serious damage to refractories and boiler.

Before any patches can be made to brick surfaces all slag and loose particles must be removed. If the patch is to be shallow such as replacing spalled material, an application of Green Cote as described before can be made by spraying, brushing or troweling. If the extent of the repair is greater than this, the defective area should be removed back to solid brick or plastic.

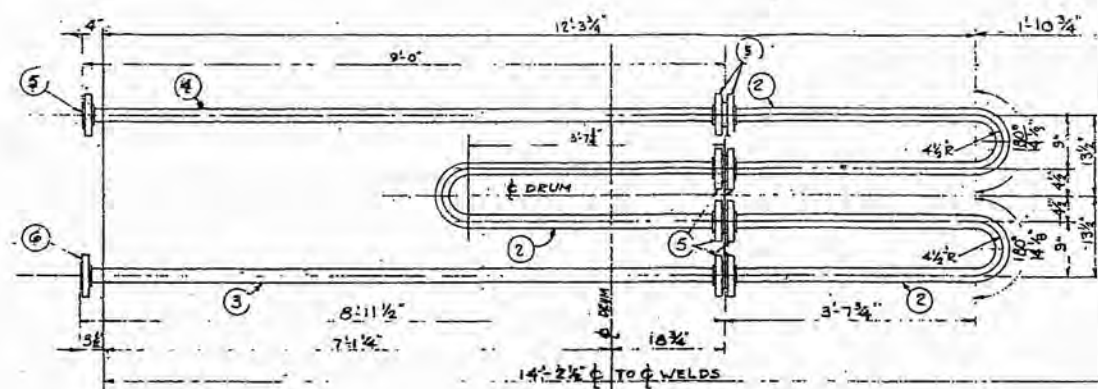
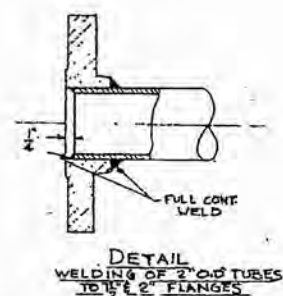
The sides of the hole should be dove tailed to provide anchorage and Super Plastic rammed into the patch.

Inspection and necessary repair to the furnace lining will help to provide long and trouble free refractory life.



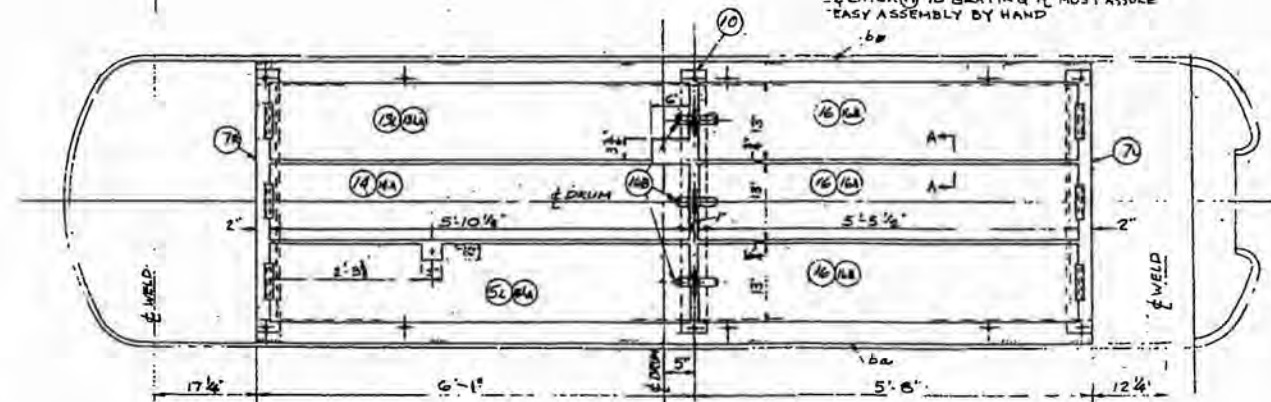
U-BOLTS SEE DWG.D-291-254

Misc. NUTS & BOLTS

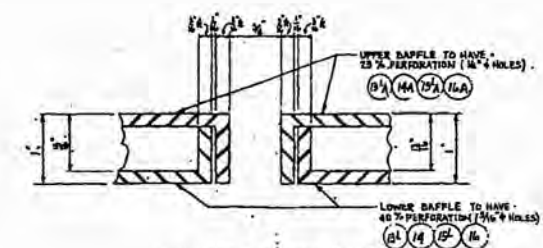


### DESUPERHEATER PIPING (1)

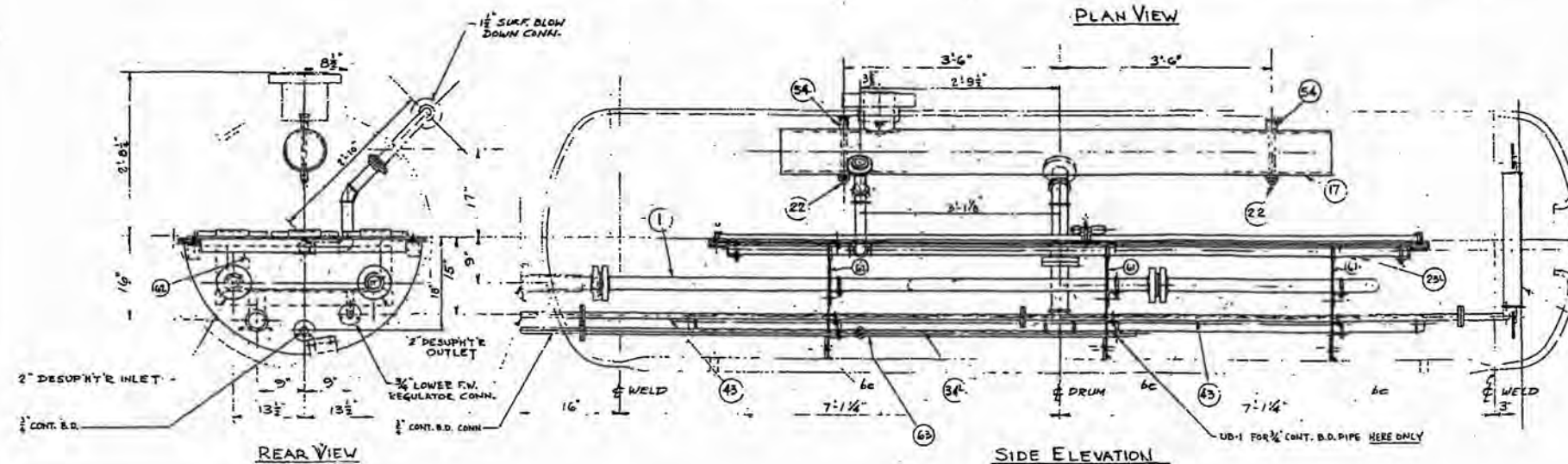
NOTE:-  
WELDING OF BASES OF GRATING LATCH  
- & CATCH (1) TO GRATING PL MUST ASSURE  
EASY ASSEMBLY BY HAND



PLAN VIEW

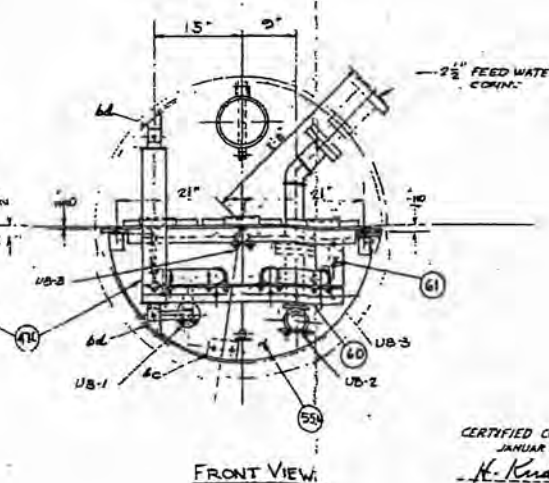


TYPICAL SECTION 'A-A'



REAR VIEW

SIDE ELEVATION



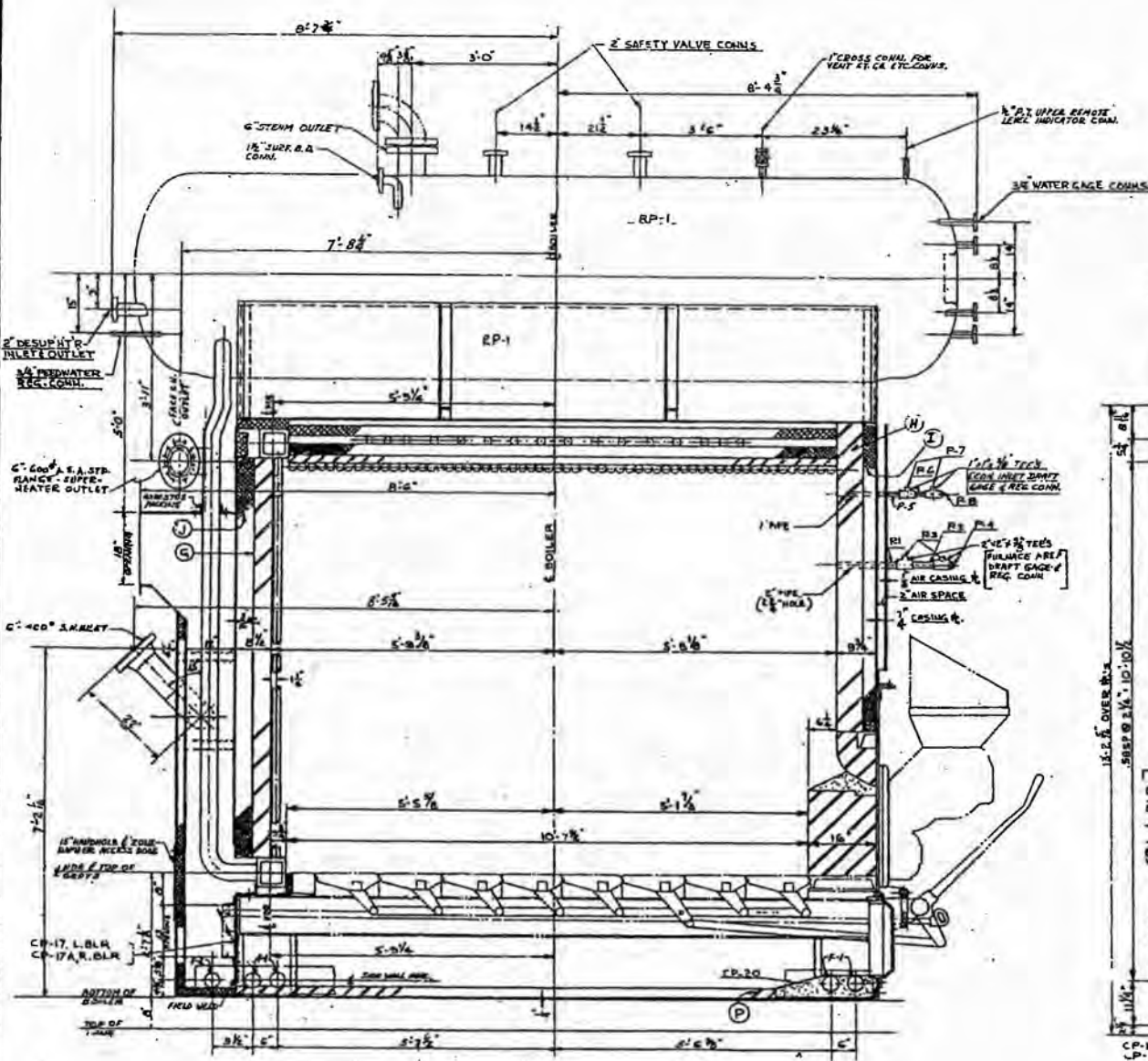
FRONT VIEW.

AS SHOWN FOR B-4628 AND B-4630  
OPP HAND FOR B-4629 AND B-4631.

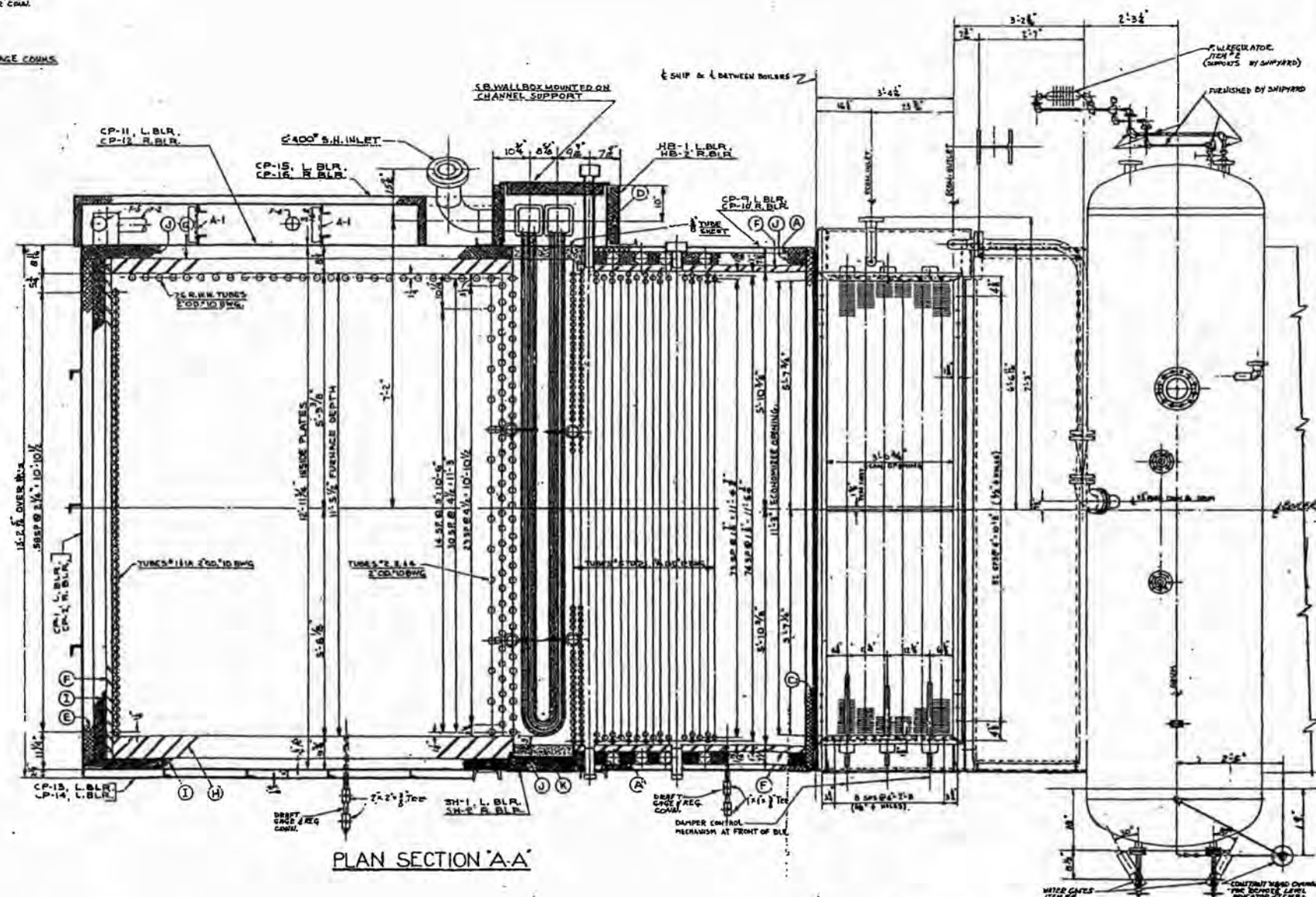
CERTIFIED CORRECT  
JANUAR 21, 1951  
H. Knackstedt  
H. KNACKSTEDT

LMCF00131

1	P.C. 57	CHARGED 2-BALL J.C. BARRON ON "SUPPORT ANGLE" 7E.	E.
LETTER	DATE	DESCRIPTION	
REVISIONS			
ARRANGEMENT OF DRUM INTERNALS			
 <p>This Drawing is the Property of the  <b>FORSTER WHEELER CORPORATION</b>          1185 BROADWAY, NEW YORK</p> <p>THIS IS A LIMITED WARRANTY COMMERCIAL DRAWING. IT IS NOT TO BE REPRODUCED OR TRANSMITTED IN ANY FORM OR BY ANY MEANS, ELECTRONIC OR MECHANICAL, INCLUDING PHOTOCOPYING, RECORDING, OR BY ANY INFORMATION STORAGE AND RETRIEVAL SYSTEM, WITHOUT THE WRITTEN PERMISSION OF THE FORSTER WHEELER CORPORATION. ANY UNAUTHORIZED REPRODUCTION OR TRANSMISSION IS STRICTLY PROHIBITED AND WILL BE PROSECUTED TO THE FULL EXTENT OF THE LAW.</p>			
DRAWN BY:	SJK	SCALE:	1/8" = 1"
CHECKED BY:	GH	DATE:	11/1/57
APPROVED BY:	NY 500-504		



SECTIONAL ELEVATION 'B-B'



PLAN SECTION 'A-A'

CERTIFIED CORRECT  
JANUARY 11, 1951  
H. K. Knecht  
H. Knecht

LETTER	DATE	DESCRIPTION
K	3-15-51	IN SECT. B-B CORRECTED LENGTH & HEIGHT FOR THE 10\"/>

B	11-11-50	ADDED PORTING INSIDE PLANT (SEE DRAWING) & 1\"/>
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REVISION	DATE	DESCRIPTION
B	11-11-50	ADDED PORTING INSIDE PLANT (SEE DRAWING) & 1\"/>

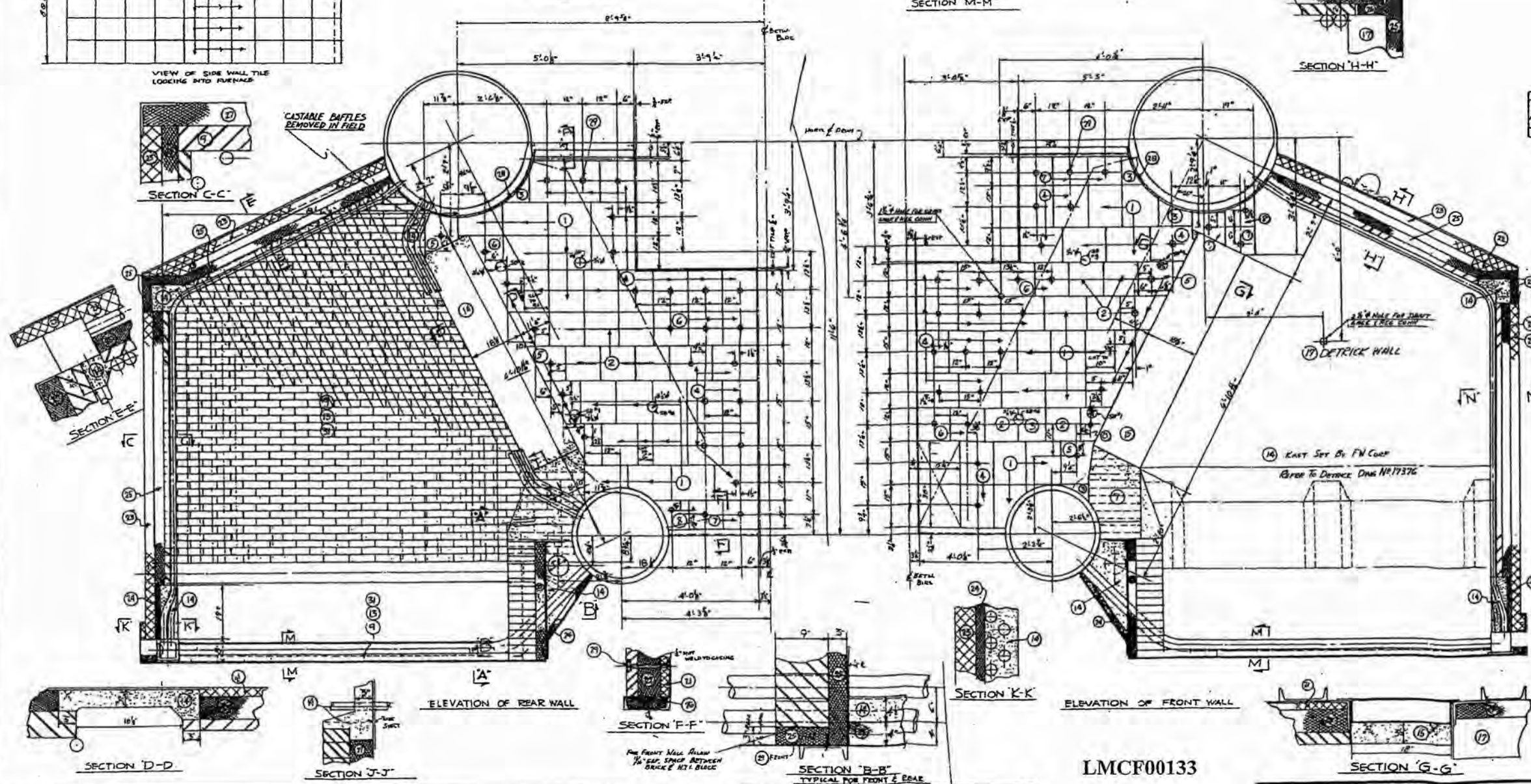
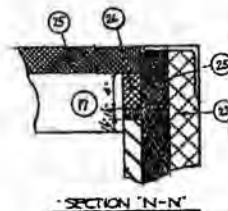
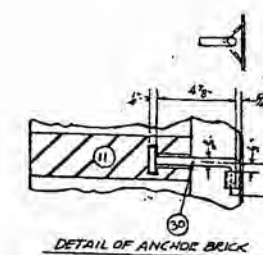
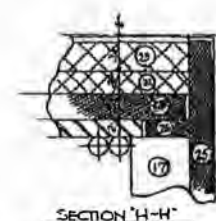
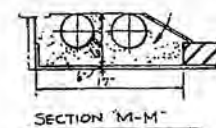
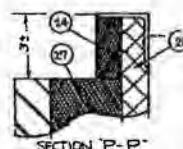
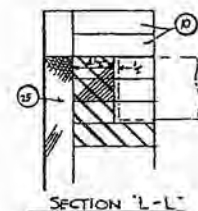
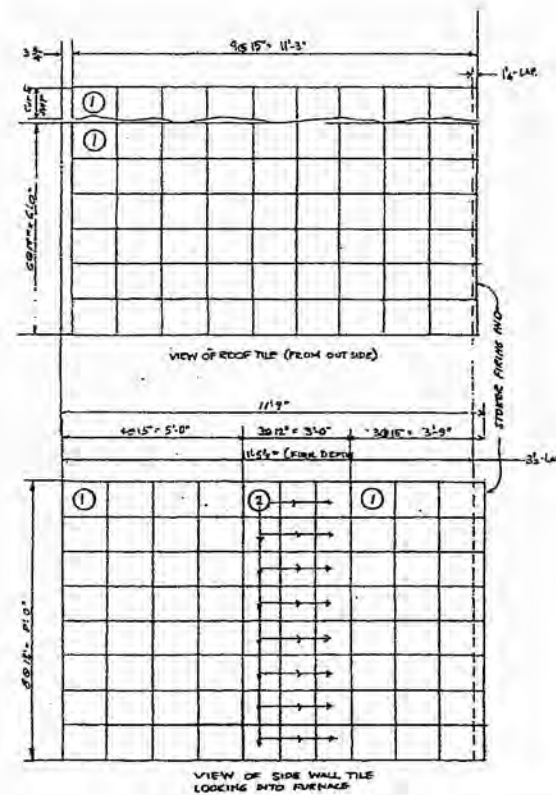
**GENERAL ARRANGEMENT  
AUXILIARY SECTIONS  
FW STEAM GENERATOR**

This Drawing is the Property of the  
**FORSTER WHEELER CORPORATION**  
100 BROADWAY, NEW YORK

SCALE: 3/4\"/>

LMCF00132

DD-105 (Rev. 3-3-50)  
DRAWN BY: JTM  
CHECKED BY: JTM  
APPROVED BY: JTM  
DATE: 1/11/51  
NY-500-440-K



BILL OF MATERIAL									
QUANTITIES FOR FOUR (4) BLS EQUALS ONE (1) SHIP									
NO	DESCRIPTION	PATT No	DWG NO	FOOTING WALL	RETAINING WALL	STANDARD 2' WALL	RETAINING WALL	5' Extension	Total
1	15' 12"x2" TIE	STD		52-	68	476		3	630
2	12' 12"x2" TIE	STD		20	24	96		7	147-
3	10x 12"x2" TIE	STD		16-	4-			1	21-
4	18' 12"x2" INTER-LOCK	T-3431	NY-344-110	64	68			7	135-
5	8' 12"x2" "	T-3640	NY-344-68	24	24			3	57-
6	12' 12"x2" "	T-3430	NY-344-110	16	16			1	33-
7	10' 12"x2" "	T-364	NY-344-68	16	8			1	25-
8	10' 12"x2" "	T-368	NY-344-28	8	4			1	13
9	4' 4"x12" FIRE BRICK	INT QUALITY		90	2372	1360	1396	762	5480
10	9"x12"x2" "	SUPER DUTY					1150	50	1200
11	9' 14"x2" " ABOVE BRICK	F-4009	NY-404-762	SUPER DUTY GCL			184	10	194
12	9' 24"x24" SOPS	SUPER DUTY	GRINTT				16	1	17
13	9' 24"x24" SOPS	AT QUIN		5300	4100	3800	6000	4800	30000
14	KAST SET	INFLITY					16516	4300	10000
15	KAST-LITER TIE-OUT			10000					10000
16	LOOSE ROCKWOOD EAGLE OR FOUL	10000					9000	10	10000
17	DETROIT WALL			✓					
18	HIGH TEMP BONDING CEMENT								15000
19	FIBERGLASS ADHESIVE (FOR HIGH-TEMP BONDING)								4000
20	ASPHALTUM PAINT (HEAVY)								4000
21	15' POLYWOOD BLANKET (EAGLE OR FOUL) SHIP			15	15				30
22	75' " " " " " " " "					5			5
23	34' " " " " " " " "					58			58
24	1' HIGH-TEMP INSUL BRICK	EAGLE OR FOUL	(6' IN)	10			P4		40
25	3' " " " " " " " "			262	17	553			835
26	2' " " " " " " " "					28			28
27	6' " " " " " " " "			167	440				507
28	1' ALBISTON ROAD	AT OFFER DRAIN							1000
29	THE ANCHOR STUD	5/8"	NY-344-99	128	134			13	265
30	BECK ANCHOR	TA-3	NY-344-98				72	5	77
31	9' 4"x6" 6" SOPS	INT GULL							520
32	8' 4" R-ROCK						ROCK		1
33	* FURNACE FLOOR	* 10% EXTRA ON THESE QUANTITIES							
34	GRIND TIE KIST-100	SET TO BE PAINTED	WITH HEAVY ASPHALTUM PAINT OR WITH FIBERGLASS TAPE						
35	10' 24"x24" FIBERGLASS SUPER-INT QUALITY					200	10		210
36	5' 24"x24" FIBERGLASS SUPER-INT QUALITY					30	2		32
37	BECK ANCHOR	TA-3	NY-344-98						12

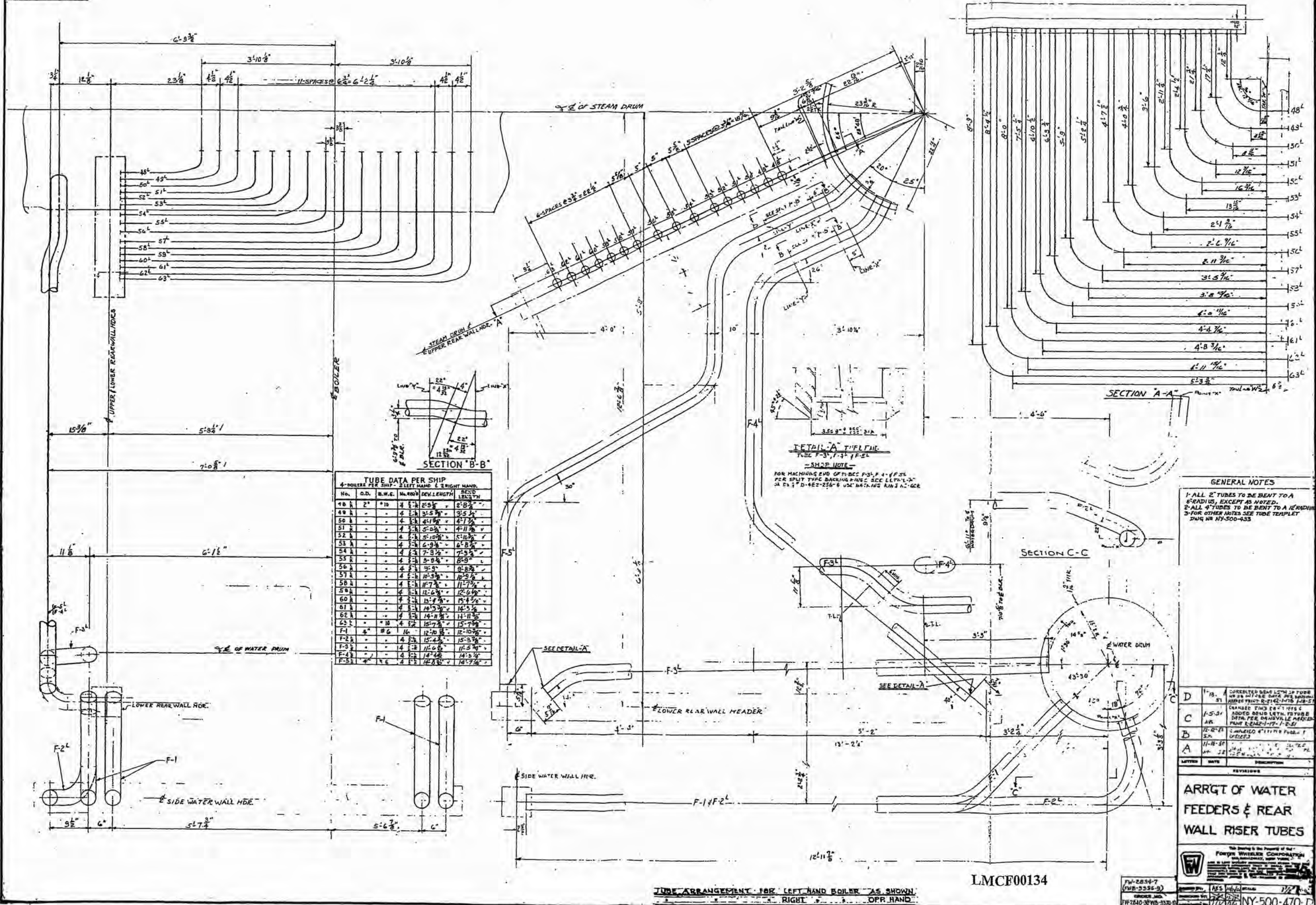
CERTIFIED CORRECT	
JANUARY 12, 1953	
<i>H. K. Knackstedt</i>	
H. K. KNACKSTEDT	
F	6-30-51 EG. <i>7/2</i> CHANGED TOTAL CAPACITY OF ITEM IN FROM 3000 TO 1000 IN AGREEMENT WITH NY LINE LETTERS
E	1-22-51 1-22-51 IN R.N. K. KNACKSTEDT QUANT ITEM 21, 22, 23, 24, 25, 26, 27, 28, 29, 30, 31, 32, 33, 34, 35, 36, 37, 38, 39, 40, 41, 42, 43, 44, 45, 46, 47, 48, 49, 50, 51, 52, 53, 54, 55, 56, 57, 58, 59, 60, 61, 62, 63, 64, 65, 66, 67, 68, 69, 70, 71, 72, 73, 74, 75, 76, 77, 78, 79, 80, 81, 82, 83, 84, 85, 86, 87, 88, 89, 90, 91, 92, 93, 94, 95, 96, 97, 98, 99, 100, 101, 102, 103, 104, 105, 106, 107, 108, 109, 110, 111, 112, 113, 114, 115, 116, 117, 118, 119, 120, 121, 122, 123, 124, 125, 126, 127, 128, 129, 130, 131, 132, 133, 134, 135, 136, 137, 138, 139, 140, 141, 142, 143, 144, 145, 146, 147, 148, 149, 150, 151, 152, 153, 154, 155, 156, 157, 158, 159, 160, 161, 162, 163, 164, 165, 166, 167, 168, 169, 170, 171, 172, 173, 174, 175, 176, 177, 178, 179, 180, 181, 182, 183, 184, 185, 186, 187, 188, 189, 190, 191, 192, 193, 194, 195, 196, 197, 198, 199, 200, 201, 202, 203, 204, 205, 206, 207, 208, 209, 210, 211, 212, 213, 214, 215, 216, 217, 218, 219, 220, 221, 222, 223, 224, 225, 226, 227, 228, 229, 230, 231, 232, 233, 234, 235, 236, 237, 238, 239, 240, 241, 242, 243, 244, 245, 246, 247, 248, 249, 250, 251, 252, 253, 254, 255, 256, 257, 258, 259, 260, 261, 262, 263, 264, 265, 266, 267, 268, 269, 270, 271, 272, 273, 274, 275, 276, 277, 278, 279, 280, 281, 282, 283, 284, 285, 286, 287, 288, 289, 290, 291, 292, 293, 294, 295, 296, 297, 298, 299, 300, 301, 302, 303, 304, 305, 306, 307, 308, 309, 310, 311, 312, 313, 314, 315, 316, 317, 318, 319, 320, 321, 322, 323, 324, 325, 326, 327, 328, 329, 330, 331, 332, 333, 334, 335, 336, 337, 338, 339, 340, 341, 342, 343, 344, 345, 346, 347, 348, 349, 350, 351, 352, 353, 354, 355, 356, 357, 358, 359, 360, 361, 362, 363, 364, 365, 366, 367, 368, 369, 370, 371, 372, 373, 374, 375, 376, 377, 378, 379, 380, 381, 382, 383, 384, 385, 386, 387, 388, 389, 390, 391, 392, 393, 394, 395, 396, 397, 398, 399, 400, 401, 402, 403, 404, 405, 406, 407, 408, 409, 410, 411, 412, 413, 414, 415, 416, 417, 418, 419, 420, 421, 422, 423, 424, 425, 426, 427, 428, 429, 430, 431, 432, 433, 434, 435, 436, 437, 438, 439, 440, 441, 442, 443, 444, 445, 446, 447, 448, 449, 450, 451, 452, 453, 454, 455, 456, 457, 458, 459, 460, 461, 462, 463, 464, 465, 466, 467, 468, 469, 470, 471, 472, 473, 474, 475, 476, 477, 478, 479, 480, 481, 482, 483, 484, 485, 486, 487, 488, 489, 490, 491, 492, 493, 494, 495, 496, 497, 498, 499, 500, 501, 502, 503, 504, 505, 506, 507, 508, 509, 510, 511, 512, 513, 514, 515, 516, 517, 518, 519, 520, 521, 522, 523, 524, 525, 526, 527, 528, 529, 530, 531, 532, 533, 534, 535, 536, 537, 538, 539, 540, 541, 542, 543, 544, 545, 546, 547, 548, 549, 550, 551, 552, 553, 554, 555, 556, 557, 558, 559, 560, 561, 562, 563, 564, 565, 566, 567, 568, 569, 570, 571, 572, 573, 574, 575, 576, 577, 578, 579, 580, 581, 582, 583, 584, 585, 586, 587, 588, 589, 590, 591, 592, 593, 594, 595, 596, 597, 598, 599, 600, 601, 602, 603, 604, 605, 606, 607, 608, 609, 610, 611, 612, 613, 614, 615, 616, 617, 618, 619, 620, 621, 622, 623, 624, 625, 626, 627, 628, 629, 630, 631, 632, 633, 634, 635, 636, 637, 638, 639, 640, 641, 642, 643, 644, 645, 646, 647, 648, 649, 650, 651, 652, 653, 654, 655, 656, 657, 658, 659, 660, 661, 662, 663, 664, 665, 666, 667, 668, 669, 670, 671, 672, 673, 674, 675, 676, 677, 678, 679, 680, 681, 682, 683, 684, 685, 686, 687, 688, 689, 690, 691, 692, 693, 694, 695, 696, 697, 698, 699, 700, 701, 702, 703, 704, 705, 706, 707, 708, 709, 710, 711, 712, 713, 714, 715, 716, 717, 718, 719, 720, 721, 722, 723, 724, 725, 726, 727, 728, 729, 730, 731, 732, 733, 734, 735, 736, 737, 738, 739, 740, 741, 742, 743, 744, 745, 746, 747, 748, 749, 750, 751, 752, 753, 754, 755, 756, 757, 758, 759, 760, 761, 762, 763, 764, 765, 766, 767, 768, 769, 770, 771, 772, 773, 774, 775, 776, 777, 778, 779, 780, 781, 782, 783, 784, 785, 786, 787, 788, 789, 790, 791, 792, 793, 794, 795, 796, 797, 798, 799, 800, 801, 802, 803, 804, 805, 806, 807, 808

ARRANGEMENT OF  
BRICKWORK & FIELD INSULATION

**FOSTER WHEELER CORPORATION**  
100 BROADWAY, NEW YORK

DD-157 (FEB 1976)	DRAWN BY: <i>[Signature]</i>	DATE: 7-19	SCALE: 3/4" = 1'-0"
ORDER NO. DD-AOT: PWS 5370-3	CHECKED BY: <i>[Signature]</i>	DATE: 7/2/79	NY 500-719

LMCF00133





SHIPPING KEY		NOTE	
DF - FURNISHED, FABRICATED & CONSOLIDATED BY DANVILLE.		1. MATERIAL LISTED REQUIREMENTS OF & GENERAL RULE BUREAU OF SHIP	
DNF - FURNISHED BY N.Y. & SHIPPED TO DANVILLE FOR FABRICATION & CONSOLIDATION.		2. HULL #369 FOR	
D - FURNISHED BY DANVILLE.			
DC - FURNISHED BY CARTERET & SHIPPED TO DANVILLE FOR CONSOLIDATION.			
- SHIPPED DIRECT.			
DN - FURNISHED BY N.Y. & SHIPPED TO DANVILLE FOR CONSOLIDATION.			
<u>CERTIFIED CORRECT</u> - JANUARY 27, 1951 <u>H. Knackstedt</u> H. KNACKSTEDT		<div> <div> <div>D</div> <div>2/17/53</div> <div>CHG VALVE FROM TO (RES) 2-4</div> </div> <div> <div>C</div> <div>1-4-54</div> <div>ELIM</div> </div> <div> <div>B</div> <div>1/27/51</div> <div>REMS DAVIS</div> </div> <div> <div>A</div> <div>1/8/51</div> <div>CORR CORR CLIN ADDR INCH</div> </div> <div> <div>LETTER</div> <div>DATE</div> </div> </div> <div> <div>REV</div> <div> <div>LIST OF SPARE PER SHIP (</div> <div>CHESAPEAKE &amp; OH</div> </div> </div> <div> <div>THIS IS</div> <div>FOSTER</div> <div>168</div> <div>AND IN LENT WITH BORROWER'S AGRE PROUDLY COPIED INDIRECTLY NOR IS THAT FOR WHICH APPARATUS SHOWN PATENTS.</div> </div> <div> <div> <div>FW</div> <div> <div>DRAWN BY:</div> <div>WJH 1/25/50</div> </div> <div> <div>ORDER NO.</div> <div> <div>CHICKEN BY:</div> <div>1/25/50</div> </div> </div> </div> </div>	

ITEM No.	QUAN PER SHIP	DESCRIPTION	ITEM No.	QUAN PER SHIP	DESCRIPTION
1	4	YARWAY REMOTE LEVEL INDICATORS FOR FLUSH MOUNTING, EQUIPPED WITH CONSTANT HEAD CHAMBER & SHUTOFF VALVES, RANGE 0-28", GOOD FOR PRESSURES UP TO 600 #/SQ. IN. ALSO SUFFICIENT 3/8" COPPER TUBING INCLUDING ADAPTERS & FITTINGS.	11	4	1/2" EDWARD FIG. #444Y, GLOBE VALVES WITH SOCKET WELDING ENDS (SALINOMETER)
			12	4	1/2" EDWARD FIG. #444Y, GLOBE VALVES WITH SOCKET WELDING ENDS (BLR. VENT)
			13	4	1/2" EDWARD FIG. #444Y, GLOBE VALVES WITH SOCKET WELDING ENDS (ECON. VENT)
2	4	SWARTWOUT - 2 1/2" 600# STD. THERMOHYDRAULIC "SC" TYPE "SM" FEED WATER REGULATORS FOR INSTALLATION ON 2 1/2" PIPE LINE. GENERATOR TO BE OF THE SCREWED TYPE & TO BE COMPLETE WITH SOCKET WELDING STOP & DRAIN VALVES. GENERATOR TO BE SUITABLE FOR 30" DRUM CONNECTIONS.	14	8	1/2" EDWARD FIG. #444Y, GLOBE VALVES WITH SOCKET WELDING ENDS. (FEED WATER REGULATOR STOP)
			15	4	1/4" EDWARD FIG. #444Y, GLOBE VALVES WITH SOCKET WELDING ENDS (TEST GAGE)
			16	4	1/2" EDWARD FIG. #444Y-3, GLOBE VALVES WITH SOCKET WELDING ENDS, MODIFIED WITH LOCKING DEVICE. (LOCK OPEN)
3	4	10" CROSBY STEAM GAGES, TYPE "AAO", FLUSH MOUNTED, BACK CONNECTED, WITH SUITABLE SYPHONS & COCKS, GRADUATED 0-1000#. GAGES TO BE FURNISHED WITH RED HAND.	17	4	3/4" EDWARD FIG. #444Y, GLOBE VALVES WITH SOCKET WELDING ENDS (CLEANING HOSE VALVES)
4	8	JERKSON No. 7 #P BOILER WATER GAGES, COMPLETE ON 2 1/2" CENTERS, 10" VISIBLE GLASS, #76 VALVES AND ILLUMINATORS. GAGE WILL BE FURNISHED WITH SUFFICIENT CHAIN & METAL PULLS FOR OPERATION FROM FLOOR & WILL ALSO BE FURNISHED WITH A DRAIN CONNECTION SUITABLE FOR SOCKET WELDING.	18	8	3/4" EDWARD FIG. #444Y, GLOBE VALVES WITH SOCKET WELDING ENDS (WATERWALL DRAIN)
			19	4	3/4" EDWARD FIG. #444Y, GLOBE VALVES WITH SOCKET WELDING ENDS (ECON. DRAIN)
			20	8	3/4" 600# ASA STD. FLANGED GLOBE VALVES, EDWARD FIG. #4828 (SUPERHEATER DRAIN)
5	24	VULCAN SOOT BLOWERS ALL FITTED WITH MODEL P3 HEADS, AS FOLLOWS:- 8- 2" HYVULLOY ELEMENTS WITH HYVULLOY BEARINGS. (SUPERHEATER) 8- 2" VULCROM ELEMENTS WITH VULITE BEARINGS. (BOILER BANK) 8- 2" PLAIN STEEL ELEMENTS WITH PLAIN STEEL BEARINGS. (ECONOMIZER).	21	4	1/2" 600# ASA STD. FLANGED GLOBE VALVES, EDWARD FIG. #4828 (SUPERHEATER VENT)
			22	4	1 1/2" 600# ASA STD. UNIT-TANDEM, FLANGED YARWAY FIG. #3978-3954 VALVES. TWO R.H. ASSEMBLIES & TWO L.H. ASSEMBLIES. (BOTTOM BLOW)
			23	4	2" H3" CROSBY FIG. #HS-MS-35 DRUM SAFETY VALVES SET AT 470 #/SQ. IN.
6	8	2 1/2" 600# ASA STD. FLANGED GLOBE VALVES, EDWARD FIG #2818 (FEED STOP)	24	4	2" H3" CROSBY FIG. #HS-MS-35 DRUM SAFETY VALVES SET AT 475 #/SQ. IN.
7	8	2 1/2" EDWARD FIG. #2846 H 600# ASA STD., FLANGED GLOBE CHECK VALVES, GEAR OPERATED & WITH EXTENSION STEMS 12" 0" LONG (FEED CHECK)	25	4	2" H3" CROSBY FIG. #HSA-MS-36 SUPERHEATER SAFETY VALVES SET AT 450 #/SQ. IN.
8	4	1 1/2" EDWARD FIG. #6841, 600# ASA STD., FLANGED STRAIGHT-WAY VALVES (SURFACE BLOW)	26	4	1/2" EDWARD FIG. #445Y, ANGLE VALVES WITH SOCKET WELDING ENDS. (STOP VALVES FOR DATUM CHAMBER)
9	8	3/8" EDWARD FIG. #444Y, GLOBE VALVES WITH SOCKET WELDING ENDS. (GAGE GLASS DRAIN)	27	4	1/2" EDWARD FIG. #444Y, GLOBE VALVES WITH SOCKET WELDING ENDS (STOP VALVES FOR DATUM CHAMBER)
10	4	3/8" EDWARD FIG. #444Y, GLOBE VALVES WITH SOCKET WELDING ENDS. (FEED WATER REG. DRAIN)			

CERTIFIED CORRECT  
JANUARY 27, 1951  
H. Knackstedt  
H. KNACKSTEDT

LMCF00137

## NOTES

1. QUANTITIES ARE LISTED ON A PER SHIP BASIS (4 BOILERS)
2. MATERIAL MEETS REQUIREMENTS OF U.S. COAST GUARD & GENERAL RULES OF AMERICAN BUREAU OF SHIPPING.
3. REFERENCE DRAWINGS:-  
NY-500-439 GENERAL ARRGT. & OUTSIDE VIEWS  
NY-500-440 - GENERAL ARRGT. PLAN SECTIONS.

F	2/17/52	CHGD PRESS SETTINGS ON DRUM SAFETY VALVES OF ITEMS #23, #24, & #25 FROM (495, 500 & 465) PSI TO (470, 475 & 450) PSI RESPECTIVELY AS PER CUST LTR 2-4-53
E	12/18/50	PER CUSTOMERS REQUEST CHANGED FIG. No. of VALVES FOR ITEMS #19 INCL. + ITEMS 26 & 27.
D	12/1/50	ADDED ITEM #27
C	4/29/50	REVISED DESIGNATION OF ITEM #14 & ADDED ITEM #26
B	11/25/50	DRAWING REMADE DUE TO CUSTOMER'S CHANGES & REVISIONS REQUEST BY MR. KENT DURING VISIT ON 11-20-50.
A	10/2/50	REVISED PER MR. R. A. STERN'S LETTER OF SEPT. 25, 1950.

LIST OF VALVES & FITTINGS PER SHIP  
(4 BOILERS)

CHESAPEAKE & OHIO RAILWAY CO.



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DRAWN BY:	WJM	11/25/50	SCALE: ——— = 1"=0"
CHECKED BY:			
APPROVED BY:	H.K.	11/27/50	NY-502-220-E

FWB-3396-9

FWB-3370-3